Applied linear statistics model solution manual

User Manual: Open the PDF directly: View PDF .Page Count: 298 Directly view this document at Want more? Advanced embedding details, examples, and help! Academia.edu uses cookies to personalize content, tailor ads and improve the user experience. By using our site, you agree to our collection of information through the use of cookies. To learn more, view our Privacy Policy. StudentSolutions Manual to accompanyApplied Linear Statistical ModelsFifth Edition Michael H. KutnerEmory University Christopher J. NachtsheimUniversity of Minnesota John NeterUniversity of Georgia William LiUniversity of Minnesota 2005McGraw-Hill/Irwin Chicago, ILBoston, MA PREFACE This Student Solutions Manual gives intermediate and final numerical results for all starred(*) end-of-chapter Problems with computational elements contained in Applied LinearStatistical Models, 5th edition. No solutions are given for Exercises, Projects, or CaseStudies. In presenting calculational results we frequently show, for ease in checking, more digitsthan are significant for the original data. Students and other users may obtain slightlydifferent answers than those presented here, because of different rounding procedures. Whena problem requires a percentile (e.g. of the t or F distributions) not included in the AppendixB Tables, users may either interpolate in the table or employ an available computer programfor finding the needed value. Again, slightly different values may be obtained than the onesshown here. The data sets for all Problems, Exercises, Projects and Case Studies are contained in thecompact disk provided with the text to facilitate data entry. It is expected that the studentwill use a computer or have access to computer output for all but the simplest data sets,where use of a basic calculator would be adequate. For most students, hands-on experiencein obtaining the computations by computer will be an important part of the educationalexperience in the course. While we have checked the solutions very carefully, it is possible that some errors are stillpresent. We would be most grateful to have any errors called to our attention. Errata canbe reported via the website for the book: . We acknowledge with thanks the assistance of Lexin Li and Yingwen Dong in the checkingof Chapters 1-14 of this manual. We, of course, are responsible for any errors or omissionsthat remain.
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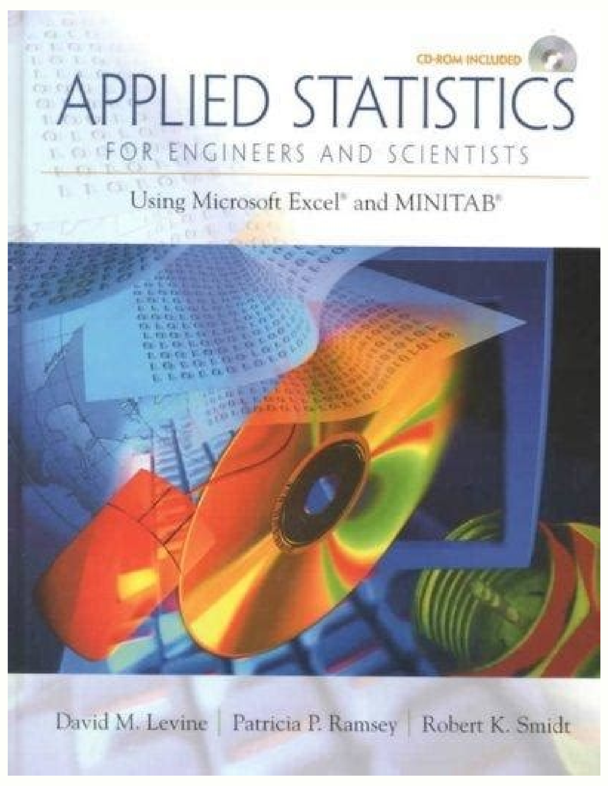

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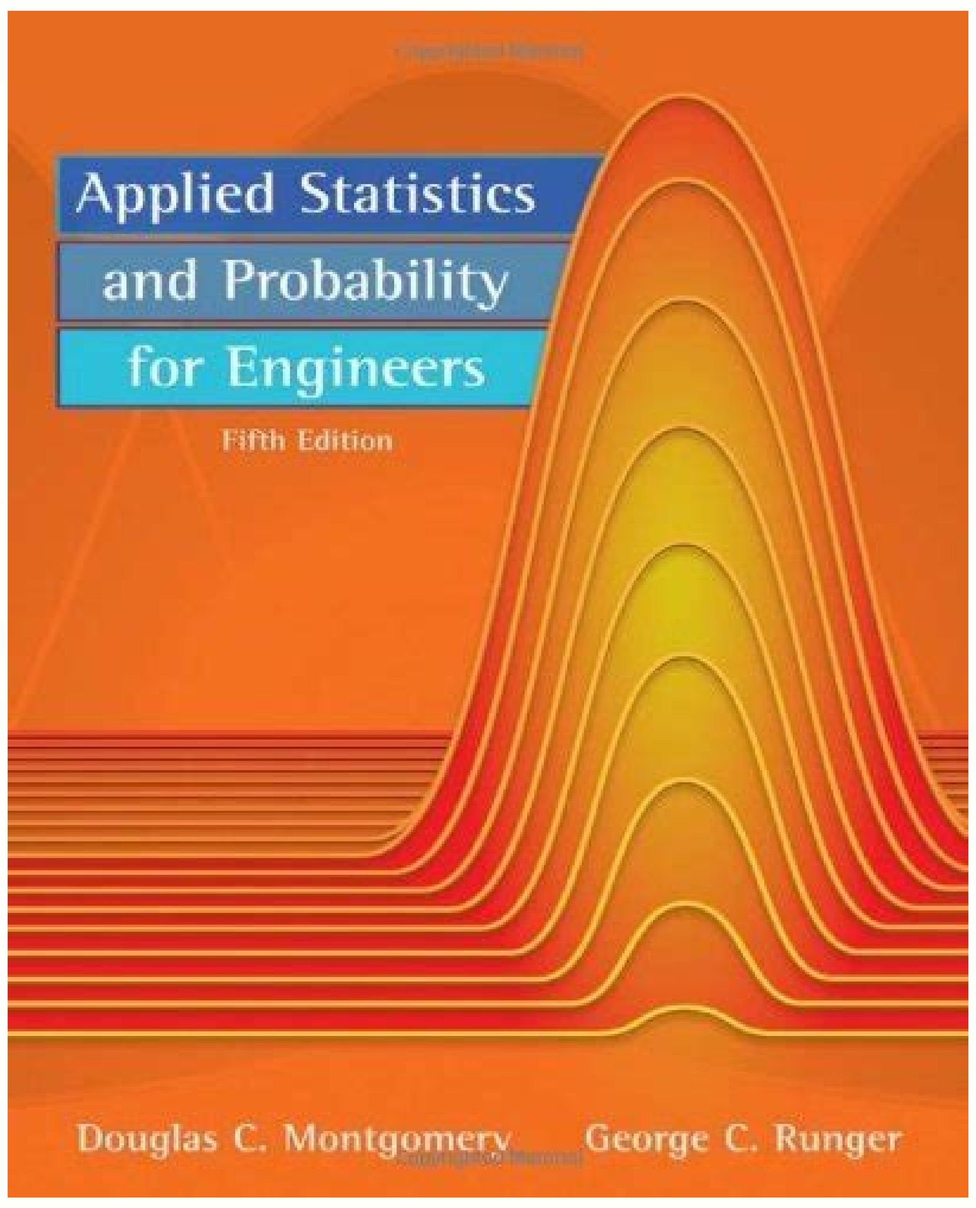

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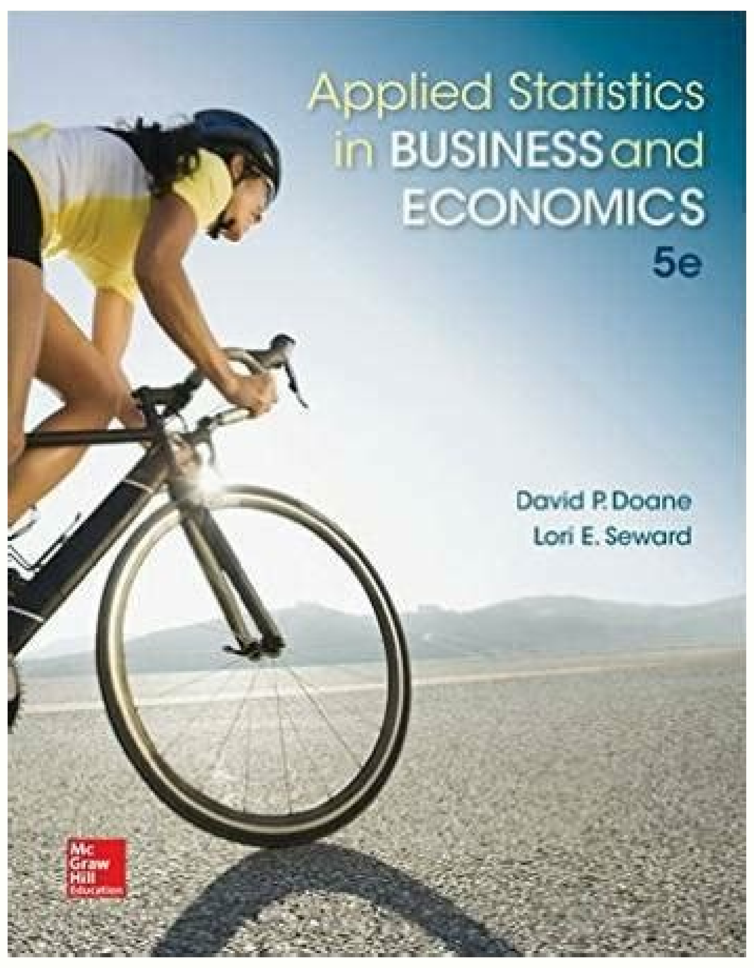

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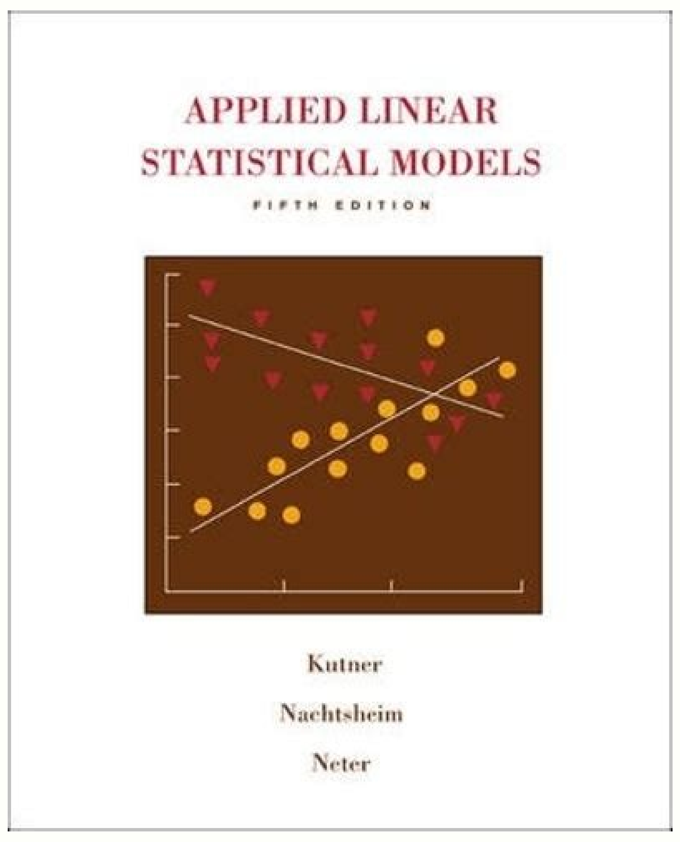

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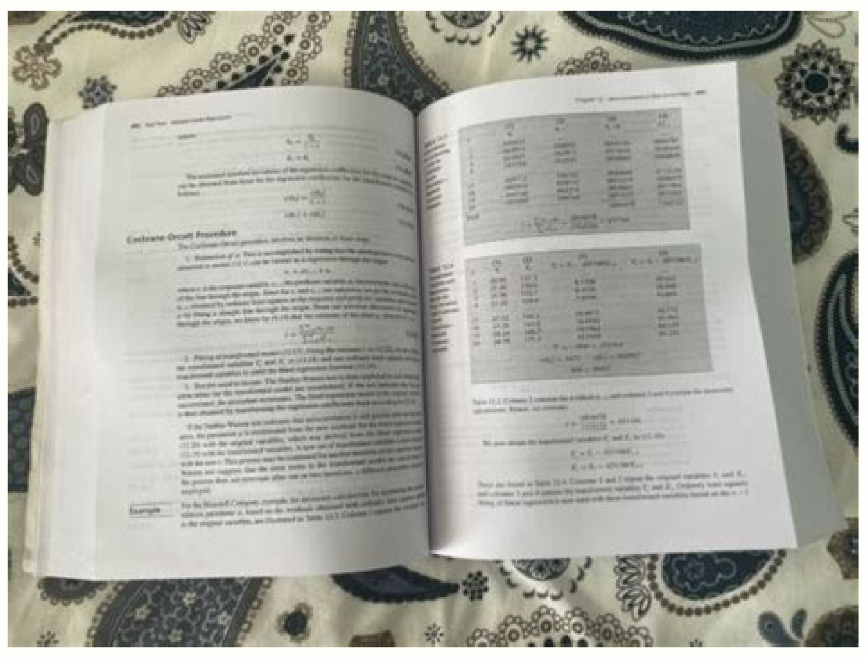

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a.Source SS df MSRegression 76,960.4 1 76,960.4Error 3,416.38 43 79.4506Total 80,376.78 44 Source SS df MSRegression 76,960.4 1 76,960.4Error 3,416.38 43 79.4506Total 80,376.78 44Correction for mean 261,747.2 1Total, uncorrected 342,124 45 b. H0: β1 = 0, Ha: β1 �= 0. F ∗ = 76, 960.4/79.4506 = 968.66, F (.90; 1, 43) = 2.826.If F ∗ ≤ 2.826 conclude H0, otherwise Ha. Conclude Ha. c. 95.75% or 0.9575, coefficient of determination d. +.9785 e. R2 2.25. a.Source SS df MSRegression 160.00 1 160.00Error 17.60 8 2.20Total 177.60 9 b. H0: β1 = 0, Ha: β1 �= 0.
F ∗ = 160.00/2.20 = 72.727, F (.95; 1, 8) = 5.32.
IfF ∗ ≤ 5.32 conclude H0, otherwise Ha. Conclude Ha. c. t∗ = (4.00 − 0)/.469 = 8.529, (t∗)2 = (8.529)2 = 72.7 = F ∗ d. R2 = .9009, r = .9492, 90.09% 2.27. a. H0: β1 ≥ 0, Ha: β1 < 0. s{b1} = 0.090197, t∗ = (−1.19 − 0)/.090197 = −13.193, t(.05; 58) = −1.67155.If t∗ ≥ −1.67155 conclude H0, otherwise Ha. Conclude Ha.P -value= 0+ c. t(.975; 58) = 2.00172, −1.19 ± 2.00172(.090197), −1.3705 ≤ β1 ≤ −1.0095 2-2 2.28. a. Yh = 84.9468, s{Yh} = 1.05515, t(.975; 58) = 2.00172, 84.9468 ± 2.00172(1.05515), 82.835 ≤ E{Yh} ≤ 87.059 b. s{Yh(new)} = 8.24101, 84.9468 ± 2.00172(8.24101), 68.451 ≤ Yh(new) ≤ 101.443 c. W 2 = 2F (.95; 2, 58) = 2(3.15593) = 6.31186, W = 2.512342,84.9468 ± 2.512342(1.05515), 82.296 ≤ β0 + β1Xh ≤ 87.598, yes, yes 2.29. a.i: 1 2 . . . 59 60 Yi − Yi: 0.823243 -1.55675 . . . -0.666887 8.09309Yi − Y : 20.2101 22.5901 . . . -14.2998 -19.0598 b.Source SS df MSRegression 11,627.5 1 11,627.5Error 3,874.45 58 66.8008Total 15,501.95 59 c. H0: β1 = 0, Ha: β1 �= 0. F ∗ = 11, 627.5/66.8008 = 174.0623,F (.90; 1, 58) = 2.79409. If F ∗ ≤ 2.79409 conclude H0, otherwise Ha. ConcludeHa. d. 24.993% or .24993 e. R2 = 0.750067, r = −0.866064 2.42. b. .95285, ρ12 c. H0 : ρ12 = 0, Ha : ρ12 �= 0.
t∗ = (.95285√ 13)/√ 1 − (.95285)2 = 11.32194,t(.995; 13) = 3.012. If |t∗| ≤ 3.012 conclude H0, otherwise Ha. Conclude Ha. d. No 2.44. a. H0 : ρ12 = 0, Ha : ρ12 �= 0. t∗ = (.87√ 101)/√ 1 − (.87)2 = 17.73321, t(.95; 101) =1.663. If |t∗| ≤ 1.663 conclude H0, otherwise Ha. Conclude Ha. b. z′ = 1.33308, σ{z′} = .1, z(.95) = 1.645, 1.33308 ± 1.645(.1), 1.16858 ≤ ζ ≤1.49758, .824 ≤ ρ12 ≤ .905 c. .679 ≤ ρ212 ≤ .819 2.47. a. -0.866064, b. H0 : ρ12 = 0, Ha : ρ12 �= 0. t∗ = (−0.866064√ 58)/√ 1 − (−0.866064)2 =−13.19326, t(.975; 58) = 2.00172. If |t∗| ≤ 2.00172 conclude H0, otherwise Ha.Conclude Ha. c. -0.8657217 d. H0 : There is no association between X and YHa : There is an association between X and Y t∗ =−0.8657217 √58√ 1 − (−0.8657217)2= −13.17243. t(0.975, 58) = 2.001717. If |t∗| ≤ 2.001717, conclude H0, otherwise, conclude Ha. Conclude Ha. 2-3 2-4 Chapter 3 DIAGNOSTICS AND REMEDIALMEASURES 3.4.c and d.i: 1 2 . . . 44 45 Yi: 29.49034 59.56084 . . . 59.56084 74.59608ei: -9.49034 0.43916 . . . 1.43916 2.40392 e.Ascending order: 1 2 . . . 44 45Ordered residual: -22.77232 -19.70183 . . . 14.40392 15.40392Expected value: -19.63272 -16.04643 . . . 16.04643 19.63272 H0: Normal, Ha: not normal. r = 0.9891. If r ≥ .9785 conclude H0, otherwiseHa. Conclude H0.
g. SSR∗ = 15, 155, SSE = 3416.38, X2BP = (15, 155/2) ÷ (3416.38/45)2 = 1.314676, χ2(.95; 1) = 3.84. If X2BP ≤ 3.84 conclude error variance constant, otherwise error variance not constant. Conclude error variance constant. 3.5. c.i: 1 2 3 4 5 6 7 8 9 10 ei: 1.8 -1.2 -1.2 1.8 -.2 -1.2 -2.2 .8 .8 .8e. Ascending Order: 1 2 3 4 5 6 7 8 9 10Ordered residual: -2.2 -1.2 -1.2 -1.2 -.2 .8 .8 .8 1.8 1.8Expected value: -2.3 -1.5 -1.0 -.6 -.2 .2 .6 1.0 1.5 2.3 H0: Normal, Ha: not normal. r = .961. If r ≥ .879 conclude H0, otherwise Ha.Conclude H0. g. SSR∗ = 6.4, SSE = 17.6, X2BP = (6.4/2) ÷ (17.6/10)2 = 1.03, χ2(.90; 1) = 2.71. If X2BP ≤ 2.71 conclude error variance constant, otherwise error variance not constant. Conclude error variance constant. Yes. 3.7.b and c.
3-1 i: 1 2 . . . 59 60ei: 0.82324 -1.55675 . . . -0.66689 8.09309Yi: 105.17676 107.55675 . . . 70.66689 65.90691 d.Ascending order: 1 2 . .
. 59 60Ordered residual: -16.13683 -13.80686 . . . 13.95312 23.47309Expected value: -18.90095 -15.75218 . . . 15.75218 18.90095 H0: Normal, Ha: not normal.
r = 0.9897. If r ≥ 0.984 conclude H0, otherwiseHa. Conclude H0. e. SSR∗ = 31, 833.4, SSE = 3, 874.45, X2BP = (31, 833.4/2) ÷ (3, 874.45/60)2 = 3.817116, χ2(.99; 1) = 6.63. If X2 BP ≤6.63 conclude error variance constant, otherwise error variance not constant. Con-clude error variance constant. Yes. 3.13. a. H0: E{Y } = β0 + β1X, Ha: E{Y } �= β0 + β1X b. SSPE = 2797.66, SSLF = 618.719, F ∗ = (618.719/8)÷(2797.66/35) = 0.967557,F (.95; 8, 35) = 2.21668. If F ∗ ≤ 2.21668 conclude H0, otherwise Ha. ConcludeH0.
3.17. b.λ: .3 .4 .5 .6 .7 SSE: 1099.7 967.9 916.4 942.4 1044.2 c. Y ′ = 10.26093 + 1.07629X e.i: 1 2 3 4 5 ei: -.36 .28 .31 -.15 .30Y ′i : 10.26 11.34 12.41 13.49 14.57 Expected value: -.24 .14 .36 -.14 .24 i: 6 7 8 9 10ei: -.41 .10 -.47 .47 -.07Y ′i : 15.64 16.72 17.79 18.87 19.95 Expected value: -.36 .04 -.56 .56 -.04 f. Y = (10.26093 + 1.07629X)2 3-2 Chapter 4 SIMULTANEOUS INFERENCESAND OTHER TOPICS INREGRESSION ANALYSIS 4.3. a. Opposite directions, negative tilt b.
B = t(.9875; 43) = 2.32262, b0 = −0.580157, s{b0} = 2.80394, b1 = 15.0352, s{b1} =0.483087 −0.580157 ± 2.32262(2.80394) −7.093 ≤ β0 ≤ 5.932 15.0352 ± 2.32262(0.483087) 13.913 ≤ β1 ≤ 16.157 c. Yes 4.4. a. Opposite directions, negative tilt b. B = t(.9975; 8) = 3.833, b0 = 10.2000, s{b0} = .6633, b1 = 4.0000, s{b1} = .4690 10.2000 ± 3.833(.6633) 7.658 ≤ β0 ≤ 12.742 4.0000 ± 3.833(.4690) 2.202 ≤ β1 ≤ 5.798 4.6. a. B = t(.9975; 14) = 2.91839, b0 = 156.347, s{b0} = 5.51226, b1 = −1.190,s{b1} =0.0901973 156.347 ± 2.91839(5.51226) 140.260 ≤ β0 ≤ 172.434 −1.190 ± 2.91839(0.0901973) − 1.453 ≤ β1 ≤ −0.927 b. Opposite directions c. No 4.7. a. F (.90; 2, 43) = 2.43041, W = 2.204727 Xh = 3: 44.5256 ± 2.204727(1.67501) 40.833 ≤ E{Yh} ≤ 48.219 Xh = 5: 74.5961 ± 2.204727(1.32983) 71.664 ≤ E{Yh} ≤ 77.528 Xh = 7: 104.667 ± 2.204727(1.6119) 101.113 ≤ E{Yh} ≤ 108.221 b. F (.90; 2, 43) = 2.43041, S = 2.204727; B = t(.975; 43) = 2.01669; Bonferroni c. Xh = 4: 59.5608 ± 2.01669(9.02797) 41.354 ≤ Yh(new) ≤ 77.767 4-1 Xh = 7: 104.667 ± 2.01669(9.05808) 86.3997 ≤ Yh(new) ≤ 122.934 4.8. a. F (.95; 2, 8) = 4.46, W = 2.987 Xh = 0: 10.2000 ± 2.987(.6633) 8.219 ≤ E{Yh} ≤ 12.181 Xh = 1: 14.2000 ± 2.987(.4690) 12.799 ≤ E{Yh} ≤ 15.601 Xh = 2: 18.2000 ± 2.987(.6633) 16.219 ≤ E{Yh} ≤ 20.181 b. B = t(.99167; 8) = 3.016, yes c. F (.95; 3, 8) = 4.07, S = 3.494 Xh = 0: 10.2000 ± 3.494(1.6248) 4.523 ≤ Yh(new) ≤ 15.877 Xh = 1: 14.2000 ± 3.494(1.5556) 8.765 ≤ Yh(new) ≤ 19.635 Xh = 2: 18.2000 ± 3.494(1.6248) 12.523 ≤ Yh(new) ≤ 23.877 d. B = 3.016, yes 4.10. a. F (.95; 2, 58) = 3.15593, W = 2.512342 Xh = 45: 102.797 ± 2.512342(1.71458) 98.489 ≤ E{Yh} ≤ 107.105 Xh = 55: 90.8968 ± 2.512342(1.1469) 88.015 ≤ E{Yh} ≤ 93.778 Xh = 65: 78.9969 ± 2.512342(1.14808) 76.113 ≤ E{Yh} ≤ 81.881 b. B = t(.99167; 58) = 2.46556, no c. B = 2.46556 Xh = 48: 99.2268 ± 2.46556(8.31158) 78.734 ≤ Yh(new) ≤ 119.720 Xh = 59: 86.1368 ± 2.46556(8.24148) 65.817 ≤ Yh(new) ≤ 106.457 Xh = 74: 68.2869 ± 2.46556(8.33742) 47.730 ≤ Yh(new) ≤ 88.843 d. Yes, yes 4.16. a.
Y = 14.9472X b. s{b1} = 0.226424, t(.95; 44) = 1.68023, 14.9472 ± 1.68023(0.226424), 14.567 ≤β1 ≤ 15.328 c. Yh = 89.6834, s{pred} = 8.92008, 89.6834 ± 1.68023(8.92008), 74.696 ≤ Yh(new) ≤104.671 4.17. b.i: 1 2 . . . 44 45 ei: -9.89445 0.21108 . . . 1.2111 2.2639 No c. H0: E{Y } = β1X, Ha: E{Y } �= β1X. SSLF = 622.12, SSPE = 2797.66, F ∗ =(622.12/9) ÷ (2797.66/35) = 0.8647783, F (.99; 9, 35) = 2.96301. If F ∗ ≤ 2.96301conclude H0, otherwise Ha. Conclude H0. P -value = 0.564 4-2 Chapter 5 MATRIX APPROACH TO SIMPLELINEAR REGRESSION ANALYSIS 5.4. (1) 503.77 (2)[5 00 160](3) [49.7 −39.2] 5.6. (1) 2,194 (2)[10 1010 20](3) [142182] 5.12.[.2 00 .00625] 5.14. a.[4 72 3] [y1 y2]= [2512] b.[y1 y2]= [4.51] 5.18. a.[W1 W2]= [14 14 14 14 12 12 −1 2 −12] Y1 Y2 Y3 Y4 b. E {[W1 W2]}= [14 [E{Y1} + E{Y2} + E{Y3} + E{Y4}]12 [E{Y1} + E{Y2} − E{Y3} − E{Y4}]] c. σ2{W} =[14 14 14 14 12 12 −1 2 −12] σ2{Y1} σ{Y1, Y2} σ{Y1, Y3} σ{Y1, Y4} σ{Y2, Y1} σ2{Y2} σ{Y2, Y3} σ{Y2, Y4}σ{Y3, Y1} σ{Y3, Y2} σ2{Y3} σ{Y3, Y4}σ{Y4, Y1} σ{Y4, Y2} σ{Y4, Y3} σ2{Y4} × 14 12 14 12 14 −1 214 −1 2 Using the notation σ2 1 for σ2{Y1}, σ12 for σ{Y1, Y2}, etc., we obtain: σ2{W1} = 116(σ 21 + +σ2 2 + σ23 + σ2 4 + 2σ12 + 2σ13 + 2σ14 + 2σ23 + 2σ24 + 2σ34) 5-1 σ2{W2} = 14(σ 21 + σ2 2 + σ23 + σ2 4 + 2σ12 − 2σ13 − 2σ14 − 2σ23 − 2σ24 + 2σ34) σ{W1, W2} = 18(σ 21 + σ2 2 − σ23 − σ2 4 + 2σ12 − 2σ34) 5.19.[3 55 17] 5.21. 5Y 21 + 4Y1Y2 + Y 2 2 5.23. a. (1)[9.940−.245](2) −.18 .04 .26 .08−.20 (3) 9.604 (4) .148 (5)[.00987 00 .000308](6) 11.41 (7) .02097 c.
.6 .4 .2 0 −.2 .4 .3 .2 .1 0.2 .2 .2 .2 .20 .1 .2 .3 .4 −.2 0 .2 .4 .6 d. .01973 −.01973 −.00987 .00000 .00987 −.01973 .03453 −.00987 −.00493 .00000−.00987 −.00987 .03947 −.00987 −.00987 .00000 −.00493 −.00987 .03453 −.01973 .00987 .00000 −.00987 −.01973 .01973 5.25.
a.
(1)[.2 −.1−.1 .1](2) [10.24.0](3) 1.8−1.2−1.2 1.8−.2 −1.2−2.2 .8 .8 .8 (4) .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .2 0 .2 −.1 .1 .2 .1 0 .2 .1 0 .2 0 .3 .1 0 .1 .2 0 .1 .2 0 .2 −.1 .1 .2 .1 0 .2 .1 −.1 .3 −.1 .5 .1 −.1 .1 .3 −.1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .2 0 .2 −.1 .1 .2 .1 0 .2 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .0 .2 0 .3 .1 0 .1 .2 0 .1 .2 0 .2 −.1 .1 .2 .1 .0 .2 5-2 (5) 17.60 (6)[.44 −.22−.22 .22](7) 18.2 (8) .44 b.
(1) .22 (2) −.22 (3) .663 c.
0 0 0 0 0 0 0 0 0 0 00 .1 −.1 .1 −.2 0 .1 0 −.1 .10 −.1 .1 −.1 .2 0 −.1 0 .1 −.10 .1 −.1 .1 −.2 0 .1 0 −.1 .10 −.2 .2 −.2 .4 0 −.2 0 .2 −.20 0 0 0 0 0 0 0 0 0 00 .1 −.1 .1 −.2 0 .1 0 −.1 .10 0 0 0 0 0 0 0 0 0 00 −.1 .1 −.1 .2 0 −.1 0 .1 −.10 .1 −.1 .1 −.2 0 .1 0 −.1 .1 5-3 5-4 Chapter 6 MULTIPLE REGRESSION – I 6.9. c. YX1 X2 X3 1.0000 .2077 .0600 .8106 1.0000 .0849 .04571.0000 .1134 1.0000 6.10. a. Y = 4149.89 + 0.000787X1 − 13.166X2 + 623.554X3 b&c.i: 1 2 . . . 51 52 ei: −32.0635 169.2051 . . . −184.8776 64.5168Expected Val.: −24.1737 151.0325 .
. .
−212.1315 75.5358 e.
n1 = 26, d1 = 145.0, n2 = 26, d2 = 77.4, s = 81.7,t∗BF = (145.0 − 77.4)/[81.7 √(1/26) + (1/26)] = 2.99, t(.995; 50) = 2.67779. If |t∗BF | ≤ 2.67779 conclude error variance constant, otherwise error variance notconstant. Conclude error variance not constant. 6.11. a. H0: β1 = β2 = β3 = 0, Ha: not all βk = 0 (k = 1, 2,3). MSR = 725, 535,MSE = 20, 531.9, F ∗ = 725, 535/20, 531.9 = 35.337, F (.95; 3, 48) = 2.79806. IfF ∗ ≤ 2.79806 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+.
b. s{b1} = .000365, s{b3} = 62.6409, B = t(.9875; 48) = 2.3139 0.000787 ± 2.3139(.000365) − .000058 ≤ β1 ≤ 0.00163 623.554 ± 2.3139(62.6409) 478.6092 ≤ β3 ≤ 768.4988 c. SSR = 2, 176, 606, SSTO = 3, 162, 136, R2 = .6883 6.12. a. F (.95; 4, 48) = 2.56524, W = 3.2033; B = t(.995; 48) = 2.6822 Xh1 Xh2 Xh3 302, 000 7.2 0:280, 000 6.9 0:350, 000 7.0 0:295, 000 6.7 1: 4292.79 ± 2.6822(21.3567)4245.29 ± 2.6822(29.7021)4279.42 ± 2.6822(24.4444)4333.20 ± 2.6822(28.9293)4917.42 ± 2.6822(62.4998) 4235.507 ≤ E{Yh} ≤ 4350.0734165.623 ≤ E{Yh} ≤ 4324.9574213.855 ≤ E{Yh} ≤ 4344.9854255.606 ≤ E{Yh} ≤ 4410.7944749.783 ≤ E{Yh} ≤ 5085.057 b.Yes, no 6-1 6.13. F (.95; 4, 48) = 2.5652, S = 3.2033; B = t(.99375; 48) = 2.5953Xh1 Xh2 Xh3 230, 000 7.5 0:250, 000 7.3 0:280, 000 7.1 0:340, 000 6.9 0: 4232.17 ± 2.5953(147.288)4250.55 ± 2.5953(146.058)4276.79 ± 2.5953(145.134)4326.65 ± 2.5953(145.930) 3849.913 ≤ Yh(new) ≤ 4614.4273871.486 ≤ Yh(new) ≤ 4629.6143900.124 ≤ Yh(new) ≤ 4653.4563947.918 ≤ Yh(new) ≤ 4705.382 6.14. a. Yh = 4278.37, s{predmean} = 85.82262, t(.975; 48) = 2.01063, 4278.37 ± 2.01063(85.82262), 4105.812 ≤ Yh(new) ≤ 4450.928 b. 12317.44 ≤ Total labor hours≤ 13352.78 6.15. b. YX1 X2 X3 1.000 −.7868 −.6029 −.6446 1.000 .5680 .56971.000 .6705 1.000 c.
Y = 158.491 − 1.1416X1 − 0.4420X2 − 13.4702X3 d&e.i: 1 2 . . . 45 46 ei: .1129 −9.0797 . .
. −5.5380 10.0524Expected Val.: −0.8186 −8.1772 . . . −5.4314 8.1772 f. No g.
SSR∗ = 21, 355.5, SSE = 4, 248.8, X2BP = (21, 355.5/2) ÷ (4, 248.8 /46)2 = 1.2516, χ2(.99; 3) = 11.3449. If X2BP ≤ 11.3449 conclude error variance constant, otherwise error variance not constant. Conclude error variance constant. 6.16. a. H0: β1 = β2 = β3 = 0, Ha: not all βk = 0 (k = 1, 2, 3). MSR = 3, 040.2, MSE = 101.2, F ∗ = 3, 040.2/101.2 = 30.05, F (.90; 3, 42) =2.2191. If F ∗ ≤ 2.2191 conclude H0, otherwise Ha. Conclude Ha. P -value =0.4878 b.
s{b1} = .2148, s{b2} = .4920, s{b3} = 7.0997, B = t(.9833; 42) = 2.1995 −1.1416 ± 2.1995(.2148) − 1.6141 ≤ β1 ≤ −0.6691 −.4420 ± 2.1995(.4920) − 1.5242 ≤ β2 ≤ 0.6402 −13.4702 ± 2.1995(7.0997) − 29.0860 ≤ β3 ≤ 2.1456 c. SSR = 9, 120.46, SSTO = 13, 369.3, R = .8260 6.17. a. Yh = 69.0103, s{Yh} = 2.6646, t(.95; 42) = 1.6820, 69.0103 ± 1.6820(2.6646),64.5284 ≤ E{Yh} ≤ 73.4922 b. s{pred} = 10.405, 69.0103 ± 1.6820(10.405), 51.5091 ≤ Yh(new) ≤ 86.5115 6-2 Chapter 7 MULTIPLE REGRESSION – II 7.4. a. SSR(X1) = 136, 366, SSR(X3|X1) = 2, 033, 566, SSR(X2|X1, X3) = 6, 674,SSE(X1, X2, X3) = 985, 530, df : 1, 1, 1,48. b.
H0: β2 = 0, Ha: β2 �= 0. SSR(X2|X1, X3) = 6, 674, SSE(X1, X2, X3) = 985, 530,F ∗ = (6, 674/1) ÷ (985, 530/48) = 0.32491, F (.95; 1, 17) = 4.04265. If F ∗ ≤4.04265 conclude H0, otherwise Ha. Conclude H0. P -value = 0.5713. c. Yes, SSR(X1)+SSR(X2|X1) = 136, 366+5, 726 = 142, 092, SSR(X2)+SSR(X1|X2) =11, 394.9 + 130, 697.1 = 142, 092.
Yes.
7.5. a. SSR(X2) = 4, 860.26, SSR(X1|X2) = 3, 896.04, SSR(X3|X2, X1) = 364.16,SSE(X1, X2, X3) = 4, 248.84, df : 1, 1, 1, 42 b. H0: β3 = 0, Ha: β3 �= 0. SSR(X3|X1, X2) = 364.16, SSE(X1, X2, X3) =4, 248.84,F ∗ = (364.16/1)÷(4, 248.84/42) = 3.5997, F (.975; 1, 42) = 5.4039. If F ∗ ≤ 5.4039conclude H0, otherwise Ha . Conclude H0. P -value = 0.065.
7.6. H0: β2 = β3 = 0, Ha: not both β2 and β3 = 0. SSR(X2, X3|X1) = 845.07,SSE(X1, X2, X3) = 4, 248.84, F ∗ = (845.07/2)÷(4, 248.84/42) =4.1768, F (.975; 2, 42) =4.0327. If F ∗ ≤ 4.0327 conclude H0, otherwise Ha. Conclude Ha. P -value = 0.022. 7.9. H0: β1 = −1.0, β2 = 0; Ha: not both equalities hold. Full model: Yi = β0 + β1Xi1 +β2Xi2 + β3Xi3 + εi, reduced model: Yi + Xi1 = β0 + β3Xi3 + εi. SSE(F) = 4, 248.84,dfF = 42, SSE(R) = 4, 427.7, dfR = 44, F ∗ = [(4427.7−4248.84)/2]÷(4, 248.84/42) = .8840, F (.975; 2, 42) = 4.0327. If F ∗ ≤ 4.0327 conclude H0, otherwise Ha. ConcludeH0. 7.13. R2Y 1 = .0431, R2 Y 2 = .0036, R212 = .0072, R2 Y 1|2 = 0.0415, R2Y 2|1 = 0.0019, R2 Y 2|13 =.0067 R2 = .6883 7.14. a.

R2Y 1 = .6190, R2 Y 1|2 = .4579, R2Y 1|23 = .4021 b. R2Y 2 = .3635, R2 Y 2|1 = .0944, R2Y 2|13 = .0189 7.17. a. Y = .17472X+1 − .04639X+ 2 + .80786X+3 b. R12 = .0072, R2 13 = .0021,R223 = .0129 7-1 c. sY = 249.003, s1 = 55274.6, s2 = 87738, s3 = .32260 b1 = 249.00355274.6 (.17472) = .00079, b2 = 249.00387738 (−.04639) = −13.16562, b3 = 249.0035.32260 (.80786) = 623.5572, b0 = 4363.04−.00079(302, 693) + 13.16562(7.37058)−623.5572(0.115385) = 4149.002. 7.18. a. Y = −.59067X+1 − .11062X+ 2 − .23393X+3 b. R212 = .32262, R2 13 = .32456, R223 = .44957 c. sY = 17.2365, s1 = 8.91809, s2 = 4.31356, s3 = .29934, b1 = 17.23658.91809 (−.59067) = −1.14162, b2 = 17.23654.31356 (−.11062) = −.44203, b3 = 17.2365.29934 (−.23393) = −13.47008, b0 = 61.5652+1.14162(38.3913) + .44203(50.4348)+13.47008(2.28696) = 158.4927 7.25. a. Y = 4079.87 + 0.000935X2 c. No, SSR(X1) = 136, 366, SSR(X1|X2) = 130, 697 d. r12 = .0849 7.26. a. Y = 156.672 − 1.26765X1 − 0.920788X2 c. No, SSR(X1) = 8, 275.3, SSR(X1|X3) = 3, 483.89 No, SSR(X2) = 4, 860.26, SSR(X2|X3) = 708.0 d. r12 = .5680, r13 = .5697, r23 = .6705 7-2 Chapter 8 MODELS FOR QUANTITATIVEAND QUALITATIVE PREDICTORS 8.4. a. Y = 82.9357 − 1.18396x + .0148405x2, R2 = .76317 b. H0: β1 = β11 = 0, Ha: not both β1 and β11 = 0. MSR = 5915.31, MSE = 64.409,F = 5915.31/64.409 = 91.8398, F(.95; 2, 57) = 3.15884. If F∗ ≤ 3.15884 concludeH0, otherwise Ha. Conclude Ha. c. Yh = 99.2546, s{Yh} = 1.4833, t(.975; 57) = 2.00247, 99.2546 ± 2.00247(1.4833),96.2843 ≤ E{Yh} ≤ 102.2249 d. s{pred} = 8.16144, 99.2546 ± 2.00247(8.16144), 82.91156 ≤ Yh(new) ≤ 115.5976 e. H0: β11 = 0, Ha: β11 ≠ 0. t∗ = .0148405/.00836 = 1.7759,t(.975; 57) = 2.0027. If |t∗| ≤ 2.00247 conclude H0, otherwise Ha. ConcludeH0. Alternatively, SSR(x2|x) = 203.1, SSE(x, x2) = 3671.31, F∗ = (203.1/1)÷(3671.31/57) = 3.15329, F(.95; 1, 57) = 4.00987. If F∗ ≤ 4.00987 conclude H0, otherwise Ha. Conclude H0. f. Y = 207.350 − 2.96432X + .0148405X2 g. rX,X2 = .9961, rx,x2 = −.0384 8.5. a.i: 1 2 3 . . . 58 59 60 ei: -1.3238 -4.7592 -3.8091 . . . -11.7798 -.8515 6.22023 b. H0: E{Y} = β0 + β1x + β11x2, Ha: E{Y} ≠ β0 + β1x + β11x2. MSLF = 62.8154,MSPE = 66.0595, F∗ = 62.8154/66.0595 = 0.95, F(.95; 29, 28) = 1.87519. If F∗ ≤ 1.87519 conclude H0, otherwise Ha. Conclude H0. c. Y = 82.92730 − 1.26789x + .01504x2 + .000337x3 H0: β111 = 0, Ha: β111 ≠ 0. t∗ = .000337/.000933 = .3612,t(.975; 56) = 2.00324. If |t∗| ≤ 2.00324 conclude H0, otherwise Ha. Con-clude H0. Yes. Alternatively, SSR(x3|x, x2) = 8.6, SSE(x, x2, x3) = 3662.78,F∗ = (8.6/1) ÷ (3662.78/56) = .13148, F(.95; 1, 56) = 4.01297. If F∗ ≤ 4.01297conclude H0, otherwise Ha. Conclude H0. Yes. 8.19. a. Y = 2.81311 + 14.3394X1 + 8.14120X2 + 1.77739X1X2 8-1 b. H0: β3 = 0, Ha : β3 ≠ 0. s{b3} = .97459, t∗ = 1.77739/.97459 = 1.8237,t(.95; 41) = 1.68288. If |t∗| ≤ 1.68288 conclude H0, otherwise Ha. Conclude Ha.Alternatively, SSR(X1X2|X1, X2) = 255.9, SSE(X1, X2, X1X2) = 3154.44, F∗ = (255.9/1)÷(3154.44/ 41) = 3.32607, F(.90; 1, 41) = 2.83208. If F∗ ≤ 2.83208conclude H0, otherwise Ha. Conclude Ha. 8-2 Chapter 9 BUILDING THE REGRESSION MODEL I: MODEL SELECTION AND VALIDATION 9.9. Variables in Model R2 p AICp Cp PRESSp None 0 262.916 88.16 13,970.10X1 .6190 220.529 8.35 5,569.56X2 .3635 244.131 42.11 9,254.49X3 .4155 240.214 35.25 8,451.43X1, X2 .6550 217.968 5.60 5,235.19X1, X3 .6761 215.061 2.81 4,902.75X2, X3 .4685 237.845 30.25 8,115.91X1, X2, X3 .6822 216.185 4.00 5,057.886 9.10. b.X1 X2 X3 X4 1 .102 .181 .327 1 .519 .3971 .782 1 c. Y = −124.3820 + .2957X1 + .0483X2 + 1.3060X3 + .5198X4 9.11. a.Subset R2 a,p X1, X3, X4 .9560X1, X2, X3, X4 .9555X1, X3 .9269X1, X2, X3 .9247 9.17. a. X1, X3 b. .10c. X1, X3 d. X1, X3 9-1 9.18.
a. X1, X3, X4 9.21. PRESS = 760.974, SSE = 660.657 9.22. a.X1 X2 X3 X4 1 .011 .177 .320 1 .344 .2211 .871 1 b. Model-building Validationdata set data set b0: −127.596 −130.652s{b0}: 12.685 12.189 b1: .348 .347s{b1}: .054 .048 b3: 1.823 1.848s{b3}: .123 .122MSE: 27.575 21.446 R2: .933 .937 c. MSPR = 486.519/25 = 19.461 d. Y = −129.664 + .349X1 + 1.840X3, s{b0} = 8.445, s{b1} = .035, s{b3} = .084 9-2 Chapter 10 BUILDING THE REGRESSIONMODEL II: DIAGNOSTICS 10.10.a&f.i: 1 2 . . . 51 52ti: −.224 1.225 . . . −1.375 .453 Di: .0003 .0245 . . . .0531 .0015 t(.9995192; 47) = 3.523.
If |ti| ≤ 3.523 conclude no outliers, otherwise outliers.Conclude no outliers. b. 2p/n = 2(4)/52 = .15385. Cases 3, 5, 16, 21, 22, 43, 44, and 48. c. Xnew = [1 300, 000 7.2 0] (X′X)−1 = 1.8628 −.0000 −.1806 .0473 .0000 −.0000 .0000.0260 −.0078 .1911 hnew, new = .01829, no extrapolation d.DFBETAS DFFITS b0 b1 b2 b3 D Case 16: −.554 −.2477 −.0598 .3248 −.4521 .0769Case 22: .055 .0304 −.0253 −.0107 .0466 .0008Case 43: .562 −.3578 .1338 .3262 .3566 .0792Case 48: −.147 .0450 −.0938 .0090 −.1022 .0035Case 10: .459 .3641 −.1044 −.3142 −.0633 .0494Case 32: −.651 .4095 .0913 −.5708 .1652 .0998Case 38: .386 −.0996 −.0827 .2084 −.1270 .0346Case 40: .397 .0738 −.2121 −.0933 −.1110 .0365 e. Case 16: .161%, case 22: .015%, case 43: .164%, case 48: .042%, case 10: .167%, case 32: .167%, case 38: .152%, case 40: .157%.
10.11.a&f.i: 1 2 . . . 45 46ti: .0116 −.9332 . . . −.5671 1.0449 Di: .000003 .015699 . . . .006400 .024702 10-1 t(.998913; 41) = 3.27. If |ti| ≤ 3.27 conclude no outliers, otherwise outliers. Con-clude no outliers. b. 2p/n = 2(4)/46 = .1739. Cases 9, 28, and 39. c. Xnew = [1 30 58 2.0] (X′X)−1 = 3.24771 .00922 −.06793 −.06730 .00046 −.00032 −.00466.00239 −.01771 .49826 hnew, new = .3267, extrapolation d.DFBETAS DFFITS b0 b1 b2 b3 DCase 11: .5688 .0991 −.3631 −.1900 .3900 .0766Case 17: .6657 −.4491 −.4711 .4432 .0893 .1051Case 27: −.6087 −.0172 .4172 −.2499 .1614 .0867 e. Case 11: 1.10%, case 17: 1.32% , case 27: 1.12%. 10.16. b. (V IF)1 = 1.0086, (V IF)2 = 1.0196, (V IF)3 = 1.0144. 10.17. b. (V IF)1 = 1.6323, (V IF)2 = 2.0032, (V IF)3 = 2.0091 10.21. a. (V IF)1 = 1.305, (V IF)2 = 1.300, (V IF)3 = 1.024 b&c.i: 1 2 3 · · · 32 33ei: 13.181 −4.042 3.060 · · · 14.335 1.396e(Y | X2, X3): 26.368 −2.038 −31.111 · · · 6.310 5.845 e(X1 | X2, X3): −.330 −.050 .856 · · · .201 .111e(Y | X1, X3): 18.734 −17.470 8.212 · · · 12.566 −8.099 e(X2 | X1, X3): −7.537 18.226 −6.993 · · · 2.401 12.888e(Y | X1, X2): 11.542 −7.756 15.022 · · · 6.732 −15.100 e(X3 | X1, X2): −2.111 −4.784 15.606 · · · −9.793 −21.247Exp. value: 11.926 −4.812 1.886 · · · 17.591 −.940 10.22.
a. Y′ = −2.0427 − .7120X′1 + .7474X′2 + .7574X′3, where Y′ = loge Y, X′1 = loge X1,X′2 = loge(140 − X2), X′3 = loge X3 b.i: 1 2 3 · · · 31 32 33 ei: −.0036 .0005 −.0316 · · · −.1487 .2863 .1208Exp. value: .0238 .0358 −.0481 · · · −.1703 .2601 .1164 c.
(V IF)1 = 1.339, (V IF)2 = 1.330, (V IF)3 = 1.016 d&e.i: 1 2 3 · · · 32 33 hii: .101 .092 .176 · · · .058 .069 .149ti: −.024 .003 −.218 · · · −.975 1.983 .829 10-2 t(.9985; 28) = 3.25. If |ti| ≤ 3.25 conclude no outliers, otherwise outliers.
Concludeno outliers. f.DFBETAS Case DFFITS b0 b1 b2 b3 D28 .739 .530 −.151 −.577 −.187 .1207 .1029 −.719 −.197 −.310 −.133 .420 .109 10-3 Chapter 11 BUILDING THE REGRESSION MODEL III: REMEDIALMEASURES 11.7. a. Y = −5.750 + .1875X e: 1 2 3 4 5 6 ei: -3.75 5.75 -13.50 -16.25 -9.75 7.50 e: 7 8 9 10 11 12ei: -10.50 26.75 14.25 -17.25 -1.75 18.50 b. SSR∗ = 123, 753.125, SSE = 2, 316.500, X2BP = (123, 753.125/2)/(2, 316.500/12)2 = 1.66, χ2(.90; 1) = 2.71. If X2 BP ≤ 2.71conclude error variance constant, otherwise error variance not constant. Concludeerror variance constant. d. v = −180.1 + 1.2437X e. i: 1 2 3 4 5 6 weight: .01456 .00315 .00518 .00315 .01456 .00518 i: 7 8 9 10 11 12weight: .00518 .00315 .01456 .00315 .01456 .00518 Y = −6.2332 + .1891X f. s{b}: s{b1}: Unweighted Weighted16.7305 13.6672 .0538 .0506 g. Y = −6.2335 + .1891X 11.10. a. Y = 3.32429 + 3.76811X1 + 5.07959X2 d. c = .07 e. Y = 6.06599 + 3.84335X1 + 4.68044X2 11.11. a. Y = 1.88602 + 15.1094X (47 cases) 11-1 Y = −.58016 + 15.0352X (45 cases) b. i: 1 2 . . . 46 47 ui: −1.4123 −.2711 . . . 4.6045 10.3331smallest weights: .13016 (case 47), .29217 (case 46) c. Y = −.5352 + 15.13552X d. 2nd iteration: Y = −1.553 + 15.425X 3rd iteration: Y = −1.6678 + 15.444X smallest weights: .12629 (case 47), .27858 (case 46) 11-2 Chapter 12 AUTOCORRELATION IN TIMESERIES DATA 12.6. H0 : ρ = 0, Ha : ρ > 0. D = 2.4015, dL = 1.29, dU = 1.38. If D > 1.38 conclude H0, if D < 1.29 conclude Ha, otherwise the test is inconclusive. Conclude H0. 12.9. a. Y = −7.7385 + 53.9533X, s{b0} = 7.1746, s{b1} = 3.5197 t: 1 2 3 4 5 6 7 8et: −.0737 −.0709 .5240 .5835 .2612 −.5714 −1.0127 −.8276 t: 9 10 11 12 13 14 15 16et: −.4714 .9352 1.803 .4947 .9435 .3156 −.6714 −1.0611 c. H0 : ρ = 0, Ha : ρ > 0. D = .857, dL = 1.10, dU = 1.37. If D > 1.37 conclude H0, if D < 1.10 conclude Ha, otherwise the test is inconclusive. Conclude Ha. 12.10. a. r = .5784, 2(1 − .5784) = .8432, D = .857 b. b0 = −.69434, b′ 1 = 50.93322 Y′ = −.69434 + 50.93322X′ s{b0} = .35091, s{b1} = 3.75590, s{b′1} = 4.34890 c. H0 : ρ = 0, Ha : ρ > 0. D = 1.476, dL = 1.08, dU = 1.36. If D > 1.36 concludeH0, if D < 1.08 conclude Ha, otherwise the test is inconclusive. Conclude H0. d. Y = −1.64692 + 50.93322X s{b0} = .83271, s{b1} = 4.34890 f. F17 = −1.64692 + 50.93322(2.210) + .5784(−.6595) = 110.534, s{pred} = .9508,t(.975; 13) = 2.160, 110.534 ± 2.160(.9508), 108.48 ≤ Y17(new) ≤ 112.59 g. t(.975; 13) = 2.160, 50.93322 ± 2.160(4.349), 41.539 ≤ β1 ≤ 60.327. 12.11. a.ρ: .1 .2 .3 .4 .5 SSE: 11.5073 10.4819 9.6665 9.0616 8.6710 ρ: .6 .7 .8 .9 1.0 SSE: 8.5206 8.5718 8.8932 9.4811 10.3408 ρ = .6 12-1 b. Y′ = −.5574 + 50.8065X′, s{b0} = .3596, s{b′1} = 4.3871 c. H0 : ρ = 0, Ha : ρ > 0. D = 1.499, dL = 1.08, dU = 1.36.
If D > 1.36 concludeH0, if D < 1.08 conclude Ha, otherwise test is inconclusive. Conclude H0. d. Y = −1.3935 + 50.8065X, s{b0} = .8990, s{b1} = 4.3871 f. F17 = −1.3935+50.8065(2.210)+.6(−.6405) = 110.505, s{pred} = .9467, t(.975; 13) = 2.160, 110.505 ± 2.160(.9467), 108.46 ≤ Y17(new) ≤ 112.55 12.12. a. b1 = 49.80564, s{b1} = 4.77891 b. H0 : ρ = 0, Ha : ρ ≠ 0. D = 1.75 (based on regression with intercept term),dL = 1.08, dU = 1.36. If D > 1.36 and 4 − D > 1.36 conclude H0, if D < 1.08 or4 − D < 1.08 conclude Ha, otherwise the test is inconclusive. Conclude H0. c. Y = −.71172 + 49.80564X, s{b1} = 4.77891 e.
F17 = −.71172 + 49.80564(2.210) − .5938 = 110.188, s{pred} = .9078, t(.975; 14) = 2.145, 110.188 ± 2.145(.9078), 108.24 ≤ Y17(new) ≤ 112.14 f. t(.975; 14) = 2.145, 49.80564 ± 2.145(4.77891), 39.555 ≤ β1 ≤ 60.056 12-2 Chapter 13 INTRODUCTION TO NONLINEARREGRESSION AND NEURALNETWORKS 13.1. a. Intrinsically linear loge f(X, γ) = γ0 + γ1X b. Nonlinear c. Nonlinear 13.3. b.
300, 3.7323 13.5. a. b0 = −.5072512, b1 = −0.0006934571, g(0)0 = 0, g (0)1 = .0006934571, g (0)2 = .6021485 b. g0 = .04823, g1 = .00112, g2 = .71341 13.6. a. Y = .04823 + .71341exp(−.00112X) City Ai: 1 2 3 4 5 Yi: .61877 .50451 .34006 .23488 .16760ei: .03123 −.04451 −.00006 .02512 .00240 Exp. value: .04125 −.04125 −.00180 .02304 .00180 i: 6 7 8Yi: .12458 .07320 .05640ei: −.02542 −.01320 −.01640 Exp.
value: .02989 −.01777 −.02304 City Bi: 9 10 11 12 13 Yi: .61877 .50451 .34006 .23488 .16760ei: .01123 −.00451 −.04006 .00512 .02240 Exp. value: .01327 −.00545 −.02989 .00545 .01777 13-1 i: 14 15 16Yi: .12458 .07320 .05640ei: −.00458 .00680 −.00640 Exp. value: −.00923 .00923 −.01327 13.7. H0 : E{Y } = γ0 + γ2 exp(−γ1X), Ha : E{Y } ≠ γ0 + γ2 exp(−γ1X). SSPE = .00290, SSE = .00707, MSPE = .00290/8 = .000363, MSLF = (.00707 − .00290)/5 = .000834, F∗ = .000834/.000363 = 2.30069, F(.99; 5, 8) = 6.6318. If F∗ ≤ 6.6318 conclude H0, otherwise Ha. Conclude H0. 13.8. s{g0} = .01456, s{g1} = .000092, s{g2} = .02277, z(.9833) = 2.128 z(.9833) = 2.128, .04823 ± 2.128(.01456) .01725 ≤ γ0 ≤ .07921 .00112 ± 2.128(.000092) .00092 ≤ γ1 ≤ .00132 .71341 ± 2.128(.02277) .66496 ≤ γ2 ≤ .76186 13.9. a. g0 = .04948, g1 = .00112, g2 = .71341, g3 = −.00250 b.
z(.975) = 1.96, s{g3} = .01211, −.00250 ± 1.96(.01211), −.02624 ≤ γ3 ≤ .02124,yes, no. 13.13. g0 = 100.3401, g1 = 6.4802, g2 = 4.8155 13.14. a. Y = 100.3401 − 100.3401/[1 + (X/4.8155)6.4802] b.i: 1 2 3 4 5 6 Yi: .0038 .3366 4.6554 11.2653 11.2653 23.1829ei: .4962 1.9634 −1.0654 .2347 −.3653 .8171 Exp. value: .3928 1.6354 −1.0519 −.1947 −.3981 .8155 2.0516 i: 8 9 10 11 12 13Yi: 39.3272 39.3272 56.2506 56.2506 70.5308 70.5308 80.8876ei: .2728 −1.4272 −1.5506 .5494 .2692 −2.1308 1.2124 Expected Val.: .1947 −1.3183 −1.6354 .5981 .0000 −2.0516 1.0519 i: 15 16 17 18 19Yi: 80.8876 87.7742 92.1765 96.7340 98.6263ei: −1.2876 −.3742 1.4235 .4660 .6737 Expected Val.: −.9974 1.3183 .7520 .4578 1.6235 −5.2242 −2.2263 Expected Val.: −.3928 1.3183 2.7520 −.8155 −2.7520 13.15. a. H0 : E{Y } = γ0 − γ0/[1 + (X/γ2)γ1] Ha : E{Y } ≠ γ0 − γ0/[1 + (X/γ2)γ1]. SSPE = 8.67999, SSE = 35.71488, MSPE = 8.67999/19 = .45684, MSLF = (35.71488 − 8.67999)/10 = 2.70349, F∗ = 2.70349/.45684 = 5.9178, F(.99; 10, 6) = 7.87. If F∗ ≤ 7.87 conclude H0, otherwise Ha. Conclude H0. 13.16. s{g0} = 1.1571, s{g1} = .1943, s{g2} = .02802, z(.985) = 2.17 100.3401 ± 2.17(1.1741) 97.7923 ≤ γ0 ≤ 102.8879 13-2 6.4802 ± 2.17(.1943) 6.0586 ≤ γ1 ≤ 6.9018 4.8155 ± 2.17(.02802) 4.7547 ≤ γ2 ≤ 4.8763 13-3 13-4 Chapter 14 LOGISTIC REGRESSION,POISSON REGRESSION, ANDGENERALIZED LINEAR MODELS 14.5. a. E{Y } = [1 + exp(−20 + .2X)]−1 b. 100 c. X = 125 : π = .006692851, π/(1 − π) = .006737947 X = 126 : π = .005486299, π/(1 − π) = .005516565 .005516565/.006737947 = .81873 = exp(−.2) 14.7. a.
b0 = −4.80751, b1 = .12508, π = [1 + exp(4.80751 − .12508X)]−1 c.
1.133 d. 5487 e. 47.22 14.11. a.j: 1 2 3 4 5 6 pj: .144 .206 .340 .592 .812 .898b. b0 = −2.07656, b1 = .13585 π = [1 + exp(2.07656 − .13585X)]−1 d. 1.14555 e. .4903 f. 23.3726 14.14. a. b0 = −1.17717, b1 = .07279, b2 = −.09899, b3 = .43397 π = [1 + exp(1.17717 − .07279X1 + .09899X2 − .43397X3)]−1 b. exp(b1) = 1.0755, exp(b2) = .9058, exp(b3) = 1.5434 c. .0642 14.15. a. z(.95) = 1.645, s{b1} = .06676, exp[.12508 ± 1.645(.06676)], 1.011 ≤ exp(β1) ≤ 1.263 b. H0 : β1 = 0, Ha : β1 ≠ 0. b1 = .12508, s{b1} = .06676, z∗ = 1.8736. If |z∗| ≤ 1.645, conclude H0, otherwise Ha. Con-clude Ha. P -value=.0609.
c. H0 : β1 = 0, Ha : β1 ≠ 0.
G2 = 3.99, χ2(.90; 1) = 2.7055. If G2 ≤ 2.7055, concludeH0, otherwise Ha. Conclude Ha. P -value=.046 14.17. a. z(.975) = 1.960, s{b1} = .004772, .13585 ± 1.960(.004772), .1265 ≤ β1 ≤ .1452, 1.1348 ≤ exp(β1) ≤ 1.1563. b. H0 : β1 = 0, Ha : β1 ≠ 0. b1 = .13585, s{b1} = .004772, z∗ = .13585/.004772=28.468. z(.975) = 1.960, |z∗| ≤ 1.960, conclude H0, otherwise conclude Ha. Conclude Ha. P -value 0+. c. H0 : β1 = 0, Ha : β1 ≠ 0. G2 = 1095.99, χ2(.95; 1) = 3.8415. If G2 ≤ 3.8415,conclude H0, otherwise Ha. Conclude Ha. P -value 0+. 14.20. a.
z(1 − .1/[2(2)]) = z(.975) = 1.960, s{b1} = .03036, s{b2} = .03343, exp{30[.07279±1.960(.03036)]}, 1.49 ≤ exp(30β1) ≤ 52.92, exp{25[−.09899±1.960(.03343)]}, .016 ≤ exp(25β2) ≤ .433. b. H0 : β3 = 0, Ha : β3 ≠ 0. b3 = .43397, s{b3} = .52132, z∗ = .43397/.52132 = .8324. z(.975) = 1.96, |z∗| ≤ 1.96, conclude H0, otherwise conclude Ha. Conclude H0. P -value=.405. c. H0 : β3 = β4 = β5 = 0, Ha : not all βk = 0, for k = 3, 4, 5. G2 = 1.534,χ2(.95; 3) = 7.81. If G2 ≤ 7.81, conclude H0, otherwise conclude Ha. Conclude H0. 14.22. a. X1 enters in step 1; X2 enters in step 2; no variables satisfy criterion for entry in step 3. b. X11 is deleted in step 1; X12 is deleted in step 2; X3 is deleted in step 3; X22 isdeleted in step 4; X1 and X2 are retained in the model. c. The best model according to the AICp criterion is based on X1 and X2. AIC3 =111.795. d. The best model according to the SBCp criterion is based on X1 and X2. SBC3 =121.002. 14.23. j: 1 2 3 4 5 6Oj1: 72 103 170 296 406 449Ej1: 71.0 99.5 164.1 327.2 394.2 440.0Oj0: 428 397 330 204 94 51Ej0: 429.0 400.5 335.9 172.9 105.8 60.0 14-2 H0 : E{Y } = [1 + exp(−β0 − β1X)]−1, Ha : E{Y } ≠ [1 + exp(−β0 − β1X)]−1. X2 = 12.284, χ2(.99; 4) = 13.28. If X2 ≤ 13.28 conclude H0, otherwise Ha.
ConcludeH0. 14.25. a. Class j π′ Interval Midpoint nj pj 1 −1.1 - under −.4 −.75 10 .3 2 −.4 - under .6 .10 10 .6 3 .6 - under 1.5 1.05 10 .7 b. i: 1 2 3 · · · 28 29 30 rSPi: −.6233 1.7905 −.6233 · · · .6099 .5754 −2.0347 14.28. a.j: 1 2 3 4 5 6 7 8 Oj1: 0 1 0 2 1 8 10 8Ej1: .2 .5 1.0 1.5 2.4 3.4 4.7 10.3Oj0: 19 19 20 18 19 12 18 10Ej0: 18.8 19.5 19.0 18.5 17.6 16.6 15.3 9.7 b. H0 : E{Y } = [1 + exp(−β0 − β1X1 − β2X2 − β3X3)]−1, Ha : E{Y } ≠ [1 + exp(−β0 − β1X1 − β2X2 − β3X3)]−1. X2 = 12.116, χ2(.95; 6) = 12.59. If X2 ≤ 12.59, conclude H0, otherwise Ha. Conclude H0. P -value = .0594. c.i: 1 2 3 · · · 157 158 159 devi: −.5460 −.5137 1.1526 · · · .4248 .8679 1.6745 14.29 a.i: 1 2 3 · · · 28 29 30 hii: .1040 .1040 .1040 · · · .0946 .1017 .1017 b.i: 1 2 3 · · · 28 29 30 ΔX2 i: .3885 3.2058 .3885 · · · .4399 .3295 4.5832 Δdevi: .6379 3.0411 .6379 · · · .7384 .5663 3.1992 Di: .0225 .1860 .0225 · · · .0213 .0137 .0756 14.32 a.i: 1 2 3 · · · 157 158 159 hii: .0197 .0186 .0992 · · · .0760 .1364 .0273 b. 14-3 i: 1 2 3 · · · 157 158 159 ΔX2 i: .3824 .3222 .3862 · · · 1.8214 .4714 .8010 Δdevi: .6527 .5816 .6233 · · · .2015 .2012 .8109 i: 1 2 3 · · · 157 158 159 .0795 .6324 2.7200 Di: .0055 .0034 .0040 · · · .1079 .0104 .0122 14.35 a.i: 1 2 3 · · · 8 9 10 Ykeir: 1.0000 .9800 ... 14.38 b.
c. z(.995) = 2.576, ... 14.39 b. P(Y = 1 | X1 = .20) = ... 14.40 a. H0 : β1 = 0, Ha : β1 ≠ 0. ... 14.41 a. Y = exp(−.3.0432 ... Conclude Ha. b. ...
Xh: 0 1 2 Sh: 2.8 ... 14-5 14-6 Chapter 15 INTRODUCTION TO THE DESIGNOF EXPERIMENT ANDOBSERVATIONAL STUDIES 15.9. a. Observational. b. Factor: expenditures for research and development in the past three years. Factor levels: low, moderate, and high. c. Cross-sectional study. d. Firms. 15.14. a. Experimental. b. Factor 1: ingredient 1, with three levels (low, medium, high). Factor 2: ingredient 2, with three levels each. c. Factor-level combinations. d. Completely randomized design. e. Volunteer. 15.20. a. 23 factorial design with two replicates. c. Red. 15.23. a. H0: W = 0, Ha: W ≠ 0. t∗ = −.1915/.0112 = −17.10, t(.975, 19) = 2.093. If|t∗| > 2.093 conclude H0, otherwise conclude Ha. Conclude Ha. 15.24. a. Agree with results on page 670. They should agree. b. H0: β2 = · · · = β20 = 0, Ha: not all βk (k = 2, 3, . . . , 20) equal zero. F = F[(.23586 − .023828)/(38 − 19)] ÷ [.023828/19] = 8.90, F (.95; 19, 19) = 2.17. If F∗ ≤ 2.17 conclude H0, otherwise conclude Ha. Conclude Ha. P -value = 0+. Not of primary interest because blocking factor was used here to increase theprecision. 15-1 15-2 Chapter 16 SINGLE-FACTOR STUDIES 16.7. b. Y 1 = 9.1, Y 2 = 8.27778, Y 3 = 10.11111, Y 4 = 13.5 ... Source SS df MS Between levels 20.125 2 10.0625Error 15.362 24 .6401Total 35.487 26 e. H0: all μi are equal (i = 1, 2, 3), Ha: not all μi are equal. F∗ = 10.0625/.6401 = 15.720,F (.95; 2, 24) = 3.40. If F∗ ≤ 3.40 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ 16.10. b. Y1 = 21.500, Y2 = 27.750, Y3 = 21.417. c. eij: i j = 1 j = 2 j = 3 ...
Source SS df MS Between ages 316.722 2 158.361Error 82.167 33 2.490Total 398.889 35 ...
H0: all μi are equal (i = 1, 2, 3), Ha: not all μi are equal. F∗ = 158.361/2.490 = 63.599, F (.99; 2, 33) = 5.31. If F∗ ≤ 5.31 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ 16.11. ...
+ τ1 μ. + τ1 μ. + τ1 μ. + τ1 μ. + τ1 ...
Y = 8.07037 − 1.19259X1 + .06296X2, μ. defined in (16.63) d.Source SS df MS Regression 20.125 2 10.0625Error 15.362 24 .6401Total 35.487 26 e. H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F∗ = 10.0625/.6401 = 15.720,F (.95; 2, 24) = 3.40. If F∗ ≤ 3.40 conclude H0, otherwise Ha. Conclude Ha. 16.21. a.
Y = 23.55556 − 2.05556X1 + 4.19444X2, μ. defined in (16.63) b.Source SS df MS Regression 316.722 2 158.361Error 82.167 33 2.490Total 398.889 35 H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F∗ = 158.361/2.490 = 63.599,F (.99; 2, 33) = 5.31. If F∗ ≤ 5.31, conclude H0, otherwise Ha. Conclude Ha. 16-4 16.25. a. μ. = 7.889, φ = 2.457, 1 − β = .96 16.27. a. μ. = 56.2, φ = 3.184, 1 − β = .95 16.29. ... Chapter 17 ANALYSIS OF FACTOR LEVELMEANS 17.8. a. Y1 = 6.878, s{Y1} = .3716 ... 17.14. a. t(.995; 24) = 2.797, 6.878 ± 2.797(.3716), 5.839 ≤ μ1 ≤ 7.917 ...
... D3 = Y3 − Y1 ... 17.15. ...
H0: all D equal zero ...
Ha. 17.18. a. D1 = Y3 − Y1 = 2.750, D2 = Y3 − Y2 = ... Conclude H0. 17-4 Chapter 18 ANOVA DIAGNOSTICS ANDREMEDIAL MEASURES 18.4. a. See Problem 16.7c. b. r = .992 c. tij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 6 ... 18.7. a.
See Problem 16.10c. b. r = .984 d. tij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 6 ...
... H0: all σi are equal (i = 1, 2, 3), Ha: not all σi are equal. MSTR = .0064815, MSE = .26465, F∗L = .0064815/.26465 = .02449, F (.95; 2, 24) = 3.40. If F∗L ≤ 3.40 conclude H0, otherwise Ha. Conclude H0. 18.16. ...
P -value = .98 18.13. a. H0: all σi are equal (i = 1, 2, 3), Ha: not all σi are equal. s1 = 1.7321, s2 = 1.2881, s3 = 1.6765, ni = 12, H∗ = (1.7321)2/(1.2881)2 = 1.808, H(.99; 3, 11) = 6.75. If H∗ ≤ 6.75 conclude H0, otherwise Ha. Conclude H0. P -value > .05 b. Y1 = 21.5, Y2 = 27.5, Y3 = 21.0, MSTR = .19444, MSE = .93434, F∗L = .19444/.93434 = .21, F (.99; 2, 33) = 5.31. If F∗L ≤ 5.31 conclude H0,otherwise Ha. Conclude H0. P -value = .81 18.14. a. H0: all σi are equal (i = 1, . . . , 6), Ha: not all σi are equal. ... Conclude H0. ...
H0: all μi are equal (i = 1, . . . , 4), Ha: not all μi are equal. F∗ = 24.44, ... Conclude Ha. P -value = 0+ ...
... 18-1 18.24. ... 18-2 18-3 Chapter 19 TWO-FACTOR STUDIES WITHEQUAL SAMPLE SIZES 19.4. a. μ1. = 34, μ2. = 37 b.
α1 = μ1. − μ.. = 31 − 34 = −3, α2 = μ2. − μ.. = 37 − 34 = 3 19.7. a. E{MSE} = σ2, E{MSA} = 541.96 19.10. a. Y11 = 21.66667, Y12 = 21.33333, Y21 = 27.33333, Y22 = 27.66667, Y31 = 22.33333, Y32 = 20.50000 b. eijk: i j = 1 j = 2 ... H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F∗ = 1.53/2.389 = .64, F (.95; 2, 30) = 3.32. If F∗ ≤ 3.32 conclude H0, otherwise Ha. Conclude H0. P -value = .53 ...
H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F∗ = 158.361/2.389 = 66.29, F (.95; 2, 30) = 3.32. If F∗ ≤ 3.32 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F∗ = 5.444/2.389 = 2.28, F (.95; 1, 30) = 4.17. If F∗ ≤ 4.17 conclude H0, otherwise Ha. Conclude H0. P -value = .14 e. α ≤ .143 g. SSA = SSTR, SSB + SSAB + SSE = SSE, yes 19.14.
a. Y11 ...
2.475, Y12 = 4.600, Y13 = 4.575, Y21 ...
5.450, Y22 = 8.925, Y23 = 9.125, Y31 = 5.975, Y32 = 10.275, Y33 = 13.250 b. eijk: ...
= 98 19.15. b.Source SS df MS Treatments 373.105 8 46.638A (ingredient 1) 220.020 2 110.010B (ingredient 2) 123.660 2 61.830AB interactions 29.425 4 7.356 Error 1.625 27 .0602Total 374.730 35 c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F∗ = 7.356/.0602 = 122.19, F (.95; 4, 27) = 2.73. If F∗ ≤ 2.73 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ d.
H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F∗ = 110.010/.0602 = 1,827.41, F (.95; 2, 27) = 3.35. If F∗ ≤ 3.35 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ H0: all βj equal zero (j = 1, 2, 3), Ha: not all βj equal zero. F∗ = 61.830/.0602 = 1,027.08, F (.95; 2, 27) = 3.35. If F∗ ≤ 3.35 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ e. α ≤ .143 19.20. a. Y11 = 222.00, Y12 ...
= 106.50, Y13 = 60.50, Y21 = 62.25, Y22 ...
= 44.75, Y23 = 38.75 b. eijk: ...
r = .994 19.21. b.Source SS df MS Treatments 96, 024.37500 5 19, 204.87500A (type) 39, 447.04167 1 39, 447.04167B (years) 36, 412.00000 2 18, 206.00000AB interactions 20, 165.33333 2 10, 082.66667 Error 1, 550.25000 18 86.12500Total 97, 574.62500 23 c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F∗ = 10, 082.66667/86.12500 = 117.07, F (.99; 2, 18) = 6.01. If F∗ ≤ 6.01 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ d. H0: α1 = α2 = 0, Ha: not both α1 and α2 equal zero. F∗ = 39, 447.04167/86.12500 =458.02, F (.99; 1, 18) = 8.29. If F∗ ≤ 8.29 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ H0: all βj equal zero (j = 1, 2, 3), Ha: not all βj equal zero. F∗ = 18, 206.00000/86.12500 = 211.39, F (.99; 2, 18) = 6.01. If F∗ ≤ 6.01 conclude H0,otherwise Ha. Conclude Ha. P -value = 0+ e. α ≤ .0297 ...
Y1. = 23.94, Y2. = 23.17 c. D = .77, s{D} = .5152, t(.975; 30) = 2.042, .77±2.042(.5152), −.28 ≤ D ≤ 1.822 d. Y1. = 21.50, Y2. = 27.75, Y3. ...
21.42 e. D1 = Y1. − Y2. ...
... 19-2 Chapter 20 TWO-FACTOR STUDIES—ONECASE PER TREATMENT ...
... Chapter 21 RANDOMIZED COMPLETEBLOCK DESIGNS 21.5. b. eij: ... Conclude H0. ... Chapter 22 ANALYSIS OF COVARIANCE 22.7. a. eij: ... Conclude Ha. ... Chapter 23 TWO-FACTOR STUDIES WITH UNEQUAL SAMPLE SIZES 23.4. a. Yijk = μ.. + α1Xijk1 + α2Xijk2 + β1Xijk3 + β2Xijk4 + (αβ)11Xijk1Xijk3 + (αβ)12Xijk1Xijk4 + (αβ)21Xijk2Xijk3 + (αβ)22Xijk2Xijk4 + εijk ...
... B entries: A B1 B2 ... α1 + β1 + (αβ)11 ...
Y = 7.18333 − 3.30000X1 + .65000X2 − 2.55000X3 + .75000X4 + 1.14167X1X3 − .03333X1X4 + .16667X2X3 + .34167X2X4 ... b.Source SS df MS Regression 373.125 8 ... Error 1.625 27 ...
... Conclude H0. P -value = .19 ...
B entries: A B1 B2 ... (αβ)21 ... (αβ)22 ...

− α2 + β3 + (αβ)23 3 1 μ.. − α1 − α2 + β1 − (αβ)11 − (αβ)21 = μ.. + α3 + β1 + (αβ)31 3 2 μ.. − α1 − α2 + β2 − (αβ)12 − (αβ)22 = μ.. + α3 + β2 + (αβ)32 3 3 μ.. − α1 − α2 − β1 − β2 + (αβ)11 + (αβ)12 + (αβ)21 + (αβ)22 = μ.. + α3 + β3 + (αβ)33 d. Yijk = μ.. + α1Xijk1 + α2Xijk2 + β1Xijk3 + β2Xijk4 + εijk e. Full model: Y = 7.18704 − 3.28426X1 + .63796X2 − 2.53426X3 + .73796X4 + 1.16481X1X3 − .04074X1X4 + .15926X2X3 + .33704X2X4, SSE(F) = 1.5767 Reduced model: Y = 7.12711 − 3.33483X1 + .62861X2 − 2.58483X3 + .72861X4, SSE(R) = 29.64774 H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = (28.0707/4) ÷ (1.5767/24) = 106.82, F(.95; 4, 24) = 2.78. If F* ≤ 2.78 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ f. Y11. = 2.5333, Y12. = 4.6000, Y13. = 4.57500, Y21. = 5.45000, Y22. = 8.90000,Y23. = 9.12500, Y31. = 5.97500, Y32. = 10.27500, Y33. = 13.25000, L1 = 2.0542,L2 = 3.5625, L3 = 5.7875, L4 = 1.5083, L5 = 3.7333, L6 = 2.2250, s{L1} = .1613,s{L2} = .1695, s{L3} = .1570, s{L4} = .2346, s{L5} = .2251, s{L6} = .2310,F(.90; 8, 24) = 1.94, S = 3.9395 2±3.5 2.0542 ± 3.9395(.1613) 1.419 ≤ L1 ≤ 2.6903.5625 ± 3.9395(.1695) 2.895 ≤ L2 ≤ 4.2305.7875 ± 3.9395(.1570) 5.169 ≤ L3 ≤ 6.4061.5083 ± 3.9395(.2346) .584 ≤ L4 ≤ 2.4303.7333 ± 3.9395(.2251) 2.846 ≤ L5 ≤ 4.6202.2250 ± 3.9395(.2310) 1.315 ≤ L6 ≤ 3.135 23.12. a. See Problem 19.14a. D1 = Y13. − Y11. = 2.042, D2 = Y23. − Y21. = 3.675, D3 = Y33. − Y31. = 7.275, L1 = D1 − D2 = −1.575, L2 = D1 − D3 = −5.175,MSE = .06406, s{D1} = .1790 (i = 1, 2, 3), s{L1} = .2531 (i = 1, 2), B = t(.99; 24) = 2.492 2.100 ± 2.492(.1790) 1.654 ≤ D1 ≤ 2.5463.675 ± 2.492(.1790) 3.229 ≤ D2 ≤ 4.1217.275 ± 2.492(.1790) 6.829 ≤ D3 ≤ 7.721 −1.575 ± 2.492(.2531) −2.206 ≤ L1 ≤ −.944−5.175 ± 2.492(.2531) −5.806 ≤ L2 ≤ −4.544 b. H0: μ12 = μ13 = 0, Ha: μ12 ≠ μ13 ≠ 0. D = Y12. − Y13. = .025, s{D} = .1790,t* = .025/.1790 = .14, t(.99; 24) = 2.492. If |t*| ≤ 2.492 conclude H0,otherwise Ha. Conclude H0. H0: μ32 − μ33 = 0, Ha: μ32 − μ33 ≠ 0. D = Y32. − Y33. = −2.975, s{D} = .1790,t* = −2.975/.1790 = −16.62, t(.99; 24) = 2.492. If |t*| ≤ 2.492 conclude H0,otherwise Ha. Conclude Ha. ≤ a .04 23.14. a. See Problem 19.20a. D1 = Y12. − Y13. = 46.0, D2 = Y22. − Y23. = 6.0, L1 = D1 − D2 = 40.0, MSE = 88.50, s{D1} = 5.6214, s{L1} = 9.407,B = t(.99167; 15) = 2.694 46.0 ± 2.694(6.652) 28.080 ≤ D1 ≤ 63.9206.0 ± 2.694(6.652) −11.920 ≤ D2 ≤ 23.920 40.0 ± 2.694(9.407) 14.658 ≤ L1 ≤ 65.342 b. H0: μ22 − μ23 ≤ 0, Ha: μ22 − μ23 > 0. D = Y22. − Y23. = 6.0, s{D} = 6.652,t* = 6.0/6.652 = .90, t(.95; 15) = 1.753. If t* ≤ 1.753 conclude H0,otherwise Ha. Conclude H0. P-value = .19 23.16. a. Yij = μ.. + ρ1Xij1 + ρ2Xij2 + ρ3Xij3 + ρ4Xij4 + ρ5Xij5 + ρ6Xij6 + ρ7Xij7 + ρ8Xij8 + ρ9Xij9 + τ1Xij10 + τ2Xij11 + εij 23-6 1 if experimental unit from block 1 0 otherwise Xij2, . . . , Xij9 are defined similarly 1 if experimental unit received treatment 1Xij10 = −1 if experimental unit received treatment 3 0 otherwise 1 if experimental unit received treatment 2Xij11 = −1 if experimental unit received treatment 3 0 otherwise b. Y = 77.10000 + 4.90000X1 + 3.90000X2 + 2.23333X3 + 3.90000X6 − 1.10000X7 − 3.76667X8 − 4.10000X9 + .25000X10 − 2.50000X11 c.Source SS df MS Regression 1, 728.3667 1 157.1242X1, X2, X3, X4, X5, X6,X7, X8,X9 453.3667 9 48.15X10,X11|X1, X2, X3, X4, X5, X6,X7, X8,X9 1, 295.0000 2 647.5000Error 112.3333 18 6.2407Total 1, 840.7000 29 d. H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F* = (1, 295.0000/2) ÷ (112.3333/18) = 103.754, F(.95; 2, 18) = 3.55. If F* ≤ 3.55 conclude H0, otherwise Ha. Conclude Ha. 23.18. a. Yij = μ.. + ρi + τj + εij Yij = μ.. + ρ1Xij1 + ρ2Xij2 + ρ3Xij3 + ρ4Xij4 + ρ5Xij5 + ρ6Xij6 + ρ7Xij7 + ρ8Xij8 + τ1Xij9 + τ2Xij10 + εij 1 if experimental unit from block 1 −1 if experimental unit from block 10 0 otherwise Xij2, . . . , Xij9 are defined similarly 1 if experimental unit received treatment 1Xij10 = −1 if experimental unit received treatment 3 0 otherwise 1 if experimental unit received treatment 2Xij11 = −1 if experimental unit received treatment 3 0 otherwise b. Full model: Y = 77.15556 + 4.84444X1 + 4.40000X2 + 2.17778X3 +3.17778X4 + 1.17778X5 + .84444X6 + 1.15556X7 −3.82222X8 − 4.15556X9 + .15556X10 − 2.55556X11 SSE(F) = 110.2222 Reduced model: Y = 76.70000 + 5.30000X1 + .30000X2 + 2.63333X3 +3.63333X4 + 1.63333X5 + 1.30000X6 − .70000X7 − 3.36667X8 − 3.70000X9 SSE(R) = 1, 311.3333 H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F* = (1, 200.6666/2) ÷ (110.6667/17) = 92.22, F(.95; 2, 17) = 3.59 If F* ≤ 3.59 conclude H0, otherwise Ha. Conclude Ha. 23.20. a. 3 −1 3 − 1 −1 3 − 1 = 3 −1 3 − 1 = 3 −1 3 −1 − 1 = . . . = 0. D = ... L. = 2 −1 = ... L. b. = 1. .d. f d. L. = 2. 1 = 2 0.86. 1 = 2. . 1... 1 = 2 0. 6 1 3 −1 −1 1 66.66.667, 3 3... Decomposition. The... Yij = ... Yij.. = ... F.. F = (.. 3 .. 3 .. 3 .. 2 , . 4 , . .2 . .. 2 = 38331/.6652 = 60.3, t(.975; 30) = 2.042. If |t*| ≤ 2.042 conclude H0,otherwise Ha. Conclude Ha. P-value = 53 23.23. H0: 4μ11+4μ12+4μ21 − μ22 = μ11+4μ12 − μ21 ... a. Ha: X1,X2, Y..., Y..., ... 4 2 4 1 ... .2... .2... 4... 27... .2 4... b. 27 .. 2 4 ... 2... 2... . 6 ... 2 2 ..., .. 2. .. . 2. ... ... 1... 2... 12 −2 ... 2... −1.6667 1 .. 1 2 ... 2 ... 4.. . .. . 1 2... .. . . a. Y211. = 36.1333, Y112. = 56.5000, Y121. = 52.3333, Y122. = 71.9333, Y211. = 46.9000, Y212. = 68.2667, Y221. = 64.1333, Y222. = 83.4667 b.Source SS df MS Between treatments 4, 772.25835 7 681.75119A (chemical) 788.90667 1 788.90667B (temperature) 1, 539.20167 1 1, 539.20167C (time) 2, 440.16667 1 2, 440.16667AB interactions .24000 1 .24000AC interactions .60167 1 .60167BC interactions 3.20167 1 3.20167ABC interactions 1.01667 1 1.01667Error 53.74000 16 3.35875Total 4, 825.99835 23 c. H0: all (αβγ)ijk equal zero, Ha: not all (αβγ)ijk equal zero. F* = .60167/3.35875 = .18, F(.975; 1, 16) = 6.12.

If F* ≤ 6.12 conclude H0, otherwise Ha. Conclude H0.P-value = .68 d. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = .24000/3.35875 = .07, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. Conclude H0.P-value = .81 H0: all (βγ)jk equal zero, Ha: not all (βγ)jk equal zero. F* = 2.94000/3.35875 = .875, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. Conclude H0.P-value = .79 24-1 H0: all (αγ)ik equal zero, Ha: not all (αγ)ik equal zero. F* = .20167/3.35875 = .06, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. Conclude H0.P-value = .81 H0: all (βγ)jk equal zero, Ha: not all (βγ)jk equal zero. F* = 788.90667/3.35875 = 234.88, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. Conclude Ha.P-value = 0+ H0: all βj equal zero (j = 1, 2), Ha: not all βj equal zero. F* = 1, 539.20167/3.35875 =458.27, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. Conclude Ha.P-value = 0+ H0: all γk equal zero (k = 1, 2), Ha: not all γk equal zero. F* = 2, 440.16667/3.35875 =726.51, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. ConcludeHa. P-value = 0+ e. α ≤ 1 −(1 − .025)6 = .14 f. D1 = 65.69167 − 51.25000 = 14.44167, D2 = 67.35000 − 49.59167 = 17.75833, D3 = 70.41667 − 49.87500 = 20.54167, MSE = 3.35875, s{Di} = .7482 (i = 1, 2, 3), B = t(.99167; 16) = 2.673 14.44167 ± 2.673(.7482) 9.467 ≤ D1 ≤ 13.46716.01667 ± 2.673(.7482) 14.017 ≤ D2 ≤ 18.01720.16667 ± 2.673(.7482) 18.167 ≤ D3 ≤ 22.167 b. Y222. = 83.46667, s{Y222.} = 1.0581, t(.975; 16) = 2.120, 83.46667 ± 2.120(1.0581), 81.2235 ≤ μ222 ≤ 85.7098 24.15. a. Yijkm = μ...+α1Xijkm1+β1Xijkm2+(αγ)11Xijkm3+(αβ)11Xijkm1Xijkm2+(αγ)11Xijkm1Xijkm3 + (βγ)11Xijkm2Xijkm3 + (αβγ)111Xijkm1Xijkm2Xijkm3 + εijkm Xijk1 = 1 if case from level 1 for factor A−1 if case from level 2 for factor A 1 if case from level 1 for factor B−1 if case from level 2 for factor B 1 if case from level 1 for factor C−1 if case from level 2 for factor C b. Yijkm = μ... + β1Xijkm2 + γ1Xijkm3 + (αβ)11Xijkm1Xijkm2 + (αγ)11Xijkm1Xijkm3 + (βγ)11Xijkm2Xijkm3 + (αβγ)111Xijkm1Xijkm2Xijkm3 + εijkm c.

Full model: Y = 60.01667 − 5.67500X1 − 8.06667X2 − 10.02500X3 + .04167X1X2 + .15000X1X3 − .40833X2X3 + .10000X1X2X3, 24-2 SSE(F) = 49.4933 Reduced model: Y = 61.15167 − 9.20167X2 − 8.89000X3 − 1.09333X1X2 + 1.28500X1X3 −1.54333X2X3 − 1.03500X1X2X3, SSE(R) = 667.8413 H0: α1 = 0, Ha: α1 ≠ 0. F* = (618.348/1) ÷ (49.4933/14) = 174.91, F(.975; 1, 14) = 6.298. If F* ≤ 6.298 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ d. D = μ2.. − μ1.. = α2 − α1 = −2α1 = 11.35000, s2{α1} = .18413, s{D} = .8582,t(.975; 14) = 2.145, 11.35000 ± 2.145(.8582), 9.509 ≤ D ≤ 13.191 24.17.2√ n 1.8≈ 4.1475, n = 14 24-3 24-4 Chapter 25 RANDOM AND MIXED EFFECTSMODELS 25.5. b. H0: σ2μ = 0, Ha: σ2μ > 0. F* = 5.0438/.70388 = 14.78, F(.95; 5, 114) = 2.29.

If F* ≤ 2.29 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. Y.. = .22767, nT = 120, s{Y..} = .06177, t(.975; 5) = 2.571, .22767 ± 2.571(.06177), .0689 ≤ μ. ≤ .3865 25-6. a. F(.025; 5, 114) = .1646, F(.975; 5, 114) = 2.680, L = .22583, U = 4.44098 1842 ≤ σ2μ σ2μ + σ2 ≤ .8162 b. χ2(.025; 114) = 90.351, χ2(.975; 114) = 145.441, .02427 ≤ σ2 ≤ .03908 c. s2μ = .02135 d. Satterthwaite: df = (ns2μ)2 ÷ [(MSTR)2/(r − 1) + (MSE)2/(nT − r)] = [20(.02135)]2 ÷ [(5.0787)2/5 + (.0390)2/(nT − r)] = 4.35, χ2(.025; 4) = .484, χ2(.975; 4) = 11.143, .0083 ≤ σ2μ ≤ .1916 25.7. b. H0: σ2μ = 0, Ha: σ2μ > 0. F* = .45787, MSE = .08444, F* = 5.42, F(.975; 5, 30) = 2.57, F(.975; 5) = 2.57, F2 = (F(.975; 14)) = 1.28, F3 = (F(.975; 5) = 6.02, F4 = (F(.975; 5) = 1.32, F5 = (F(.975; 5) = 2.68, F6 = (F(.975; 15) = 6.07, G1 = .6109, G2 = .2188, G3 = .0147, G4 = −.2076, HL = .014, HU = .115,.02135 − .014, .02135 + .115, .0074 ≤ σ2 μ ≤ .1364 25.16. a. H0: σ2α = 0, Ha: σ2α > 0. F* = 303.82252/.01 = 5.54, F(.99; 4, 36) = 3.89 If F* ≤ 3.89 conclude H0, otherwise Ha. Conclude Ha. P-value = .001 b. σ2α β = 50.362 c. H0: σ2α = 0, Ha: σ2α > 0. F* = 12.28952/.011 = .24, F(.99; 2, 36) = 5.25. If F* ≤ 5.25 conclude H0,otherwise Ha. Conclude H0. P-value = .79 d. Y... = 14.156/203.822 = .047, F(.99; 2, 4) = 18.0 If F* ≤ 18.0 conclude H0, otherwise Ha. Y.. = 56.133, X2 = 54.733, D1 = Y.1. − Y.2. = −.400, s{D} = 1.867, s{D} = 5.6647 (i = 1, 2, 3), q(.95; 3, 4) = 5.04, T = 5.04/√2 = 3.5638 −.400 ± 3.5638(1.6647) −6.333 ≤ D1 ≤ 5.53 −.813 ≤ D2 ≤ 6.613, 15.2 4 −6.0 ≤ D3 ≤ 6.416 ... 3.5638(6.3647) −24.083 ≤ D2 ≤ 21.283 1.867 ± 3.5638(6.3647) −20.816 ≤ D3 ≤ 24.550 f. μ1 = 56.1333, MSA = 303.82222, s2{μ1} = (2/45)(303.82222)(2/4+1(12.28889) = 13.7763, s{μ1} = 3.712, df = (13.7763)2 ÷ [{(2/45)(303.82222)}2/4+{(1/45)(12.28889)}2/2} = 4.16, t(.975; 4) = 4.60, 56.13333 ± 4.60(3.712), 39.06 ≤ μ1 ≤ 73.21 g.

MSA = 12.28889, MSB = 303.82222, F1 = F(.025; 4, 4) = .1041, F2 = F(.975; 4, 4) = 9.605, F3 = F(.025; 2, 4) = .025, F4 = F(.975; 2, 4) = 10.6, G1 = .0025, G2 = .8957, G3 = .1541, G4 = .1041, H1 = 9.605, HU = 162.7... MSE = 52.01111, s2α = (MSA − MSE)/nb = −2.648, c1 = 1/15, c2 = −1/15, df1 = 2, df2 = 36, F1 = F(.995; 2, ∞) = 5.30, F2 = F(.995; 36, ∞) = 1.71, F3 = F(.995; ∞, 2) = 200, F4 = F(.995; ∞, 36) = 2.01,F5 = F(.995; 2, 36) = 6.16, F6 = F(.995; 36, 2) = 199.5, G1 = .8113, G2 = .4152,G3 = .1022, G4 = −35.3895, HL = 3.605, HU = 162.730,−2.648 − 3.605, −2.648 + 162.730, −6.253 ≤ σ2 α ≤ 160.082 25.19. a. eij: i j 1 j = 2 j = 3 i 4 j = 51 −.175 −1.300 .325 −2.050 3.2002 .025 4.900 −3.475 1.150 −2.6003 .025 −1.100 1.525 −.850 .14006 −.075 1.100 2.525 −.850 −6007 −.175 −1.000 −.675 2.950 −1.8008 .825 −.100 1.525 −1.850 −.4000 .1700 2.029 .3 b. r = .967 c. H0: all σ2 equal (j = 1, ..., 5), Ha: not all σ2 equal. H = (94.52127) − 7(21.729, SSRem = .84, F(.95; 1, 27) = 9.34.

If F* ≤ 9.34 conclude H0, otherwise Ha. Conclude H0. P-value = .4 d. H0: σ2β = 0, Ha: σ2β > 0. F* = 33.2806/1.4 = 23.6, F(.95; 4, 24) = 2.78. If F* ≤ 2.78 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+. 25.20. a.Source SS df MS Blocks 4, 826.375 7 689.48214Paint type 531.350 4 132.83750Error 135.700 28 4.84643Total 5, 493.425 39 b. H0: all τj equal zero (j = 1, . . . , 5), Ha: not all τj equal zero. F* = 132.83750/4.84643 = 27.41, F(.95; 4, 28) = 2.71. If F* ≤ 2.71 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. Y.1 = 20.500, Y.2 = 23.625, Y.3 = 19.000, Y.4 = 29.375, Y.5 = 21.125, L1 = Y.1 − Y.2 = −3.125, L2 = Y.1 − Y.3 = 1.500, L3 = Y.1 − Y.4 = −8.875, L4 = Y.1 − Y.5 = −.625, s{Li} = 1.0448 (i = 1, . . . , 4), B = t(.9875; 28) = 2.369 −3.125 ± 2.369(1.0448) −5.60 ≤ L1 ≤ −.651.500 ± 2.369(1.0448) −.98 ≤ L2 ≤ 3.98 −8.875 ± 2.369(1.0448) −11.35 ≤ L3 ≤ −6.40−.625 ± 2.369(1.0448) −3.10 ≤ L4 ≤ 1.85 d. L = 13/Y.1 + Y.3 + Y.5 − 1/2(Y.2 + Y.4) = −6.29167, s{L} = .6744, t(.975; 28) = 2.048, −6.29167 ± 2.048(.6744), −7.67 ≤ L ≤ −4.91 25.23. a. H0: σ2αβ = 0, Ha: σ2αβ > 0.

F* = MSAB/MSE = 1.49/2.30 = .648, F(.975; 8, 60) = 2.41 If F* ≤ 2.41 conclude H0, otherwise Ha. Conclude H0.P-value = .27. b. H0: σ2αβ = 0, Ha: σ2αβ > 0. F* = MSABC/MSABC = 2.40/1.49 = 1.61, F(.99; 2, 8) = 8.65. If F* ≤ 8.65 conclude H0, otherwise Ha. Conclude H0. c.

H0: σ2β = 0, Ha: σ2β > 0. F* = F* = MSB/(MSAB + MSBC − MSABC) =4.20/(2.40+3.13−1.49) = 104, df = 16.3216/(5.6667 = 2.91, F(.99; 1, 3) = 34.1 If F* ≤ 34.1 conclude H0, otherwise Ha. Conclude H0. d. s2α = (MSA − MSAB − MSAC + MSABC)/nbc = .126, df = (8.650/20) − (2.40/30) − (3.96/30) + (1.49/30)]2 ÷(8.65/30)2/2 + (2.40/30)2/2 + (3.96/30)2/2 + (1.49/30)2/8 = .25, χ2(.025; 2) = .00, χ2(.975; 2) = 7.38, .04 ≤ σ2α ≤ 55.265, no (Note: Unrestricted estimators are same except that variance component for random effect A is zero.) b. Estimates remain the same. c. H0: σ2β = 0, Ha: σ2β > 0. F* = .02199 − 1 = .49 25.29. Chapter ... c. H0: σ2 β = 0, Ha: σ2β > 0. (.99) = 2.326, s{σ2β} = 13.33, z* = 15.666/13.333 = 1.175. If z* ≤ 2.326 conclude H0, otherwise Ha. Conclude H0. P-value = .12 d. H0: β1 = β2 = β3 = 0, Ha: not all βj = 0 (j = 1, 2, 3). −2logeL(R) = 295.385, −2logeL(F) = 295.253, X2 = 295.385 − 295.253 = .132, χ2(.99; 2) = 9.21. If X2 ≤ 9.21 conclude H0, otherwise Ha. Conclude H0. P-value = .94 e. z(.995) = 2.576, 15.666 ± 2.576(13.333), −18.680 ≤ σ2αβ ≤ 50.012 25-3 25-4 Chapter 26 NESTED DESIGNS, SUBSAMPLING, AND PARTIALLYNESTED DESIGNS 26.5. a. eijk: i = 1 k j = 1 j = 2 j = 3 j = 4 1 −3.0 −4.3 −1.2 −1.5 2 2 −2.8 −14.65 −2.2 2.6 2 −1.2 1 −1.6 2.8 −1.12 4 i = 2k j = 1 j = 2 j = 3 j = 41 −2.0 4.2 −2.8 −4.2 2 −3.8 −2.6 8.8 3.2 −15.4 −8.23 −15.2 6.4 −5.4 10.4 2.6 7.8 11.4 11.85 10.8 8 −2.2 i = 3k j = 1 j = 2 j = 3 j = 41 −3.8 −5.8 −9.8 −12.02 11.2 12.2 0.03 −8 −8.3 17.04 −12.8 3.2 2.0 5 8.2 −4.8 −7.0 r = .987 26.10. a.Source SS df MS States (A) 6, 976.84 3 2, 488.4222Cities within states [B(A)] 167.60 6 27.933Error (E) 3, 893.20 36 108.144Total 11, 037.64 44 b. H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F* = 3, 488.422/108.144 =32.257, F(.95; 2, 36) = 3.26. If F* ≤ 3.26 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c.

H0: all βj(i) equal zero, Ha: not all βj(i) equal zero. F* = 27.933/108.144 = .258,F (.95; 6, 36) = 2.36. If F* ≤ 2.36 conclude H0, otherwise Ha. Conclude H0. 26-1 P-value = .95 d. α ≤ 10 26.11 a.

Y11. = 40.2, s{Y11.} = 4.6507, t(.975; 36) = 2.0281, 40.2 ± 2.0281(4.6507), 30.77 ≤ μ11 ≤ 49.63 b. Y1.. = 40.8667, Y2.. = 57.3333, Y3.. = 26.8667, s{Yi..} = 2.6851 (i = 1, 2, 3),t(.975; 36) = 2.7195 40.8667 ± 2.7195(2.6851) 33.565 ≤ μ1. ≤ 48.16957.3333 ± 2.7195(2.6851) 50.031 ≤ μ2. ≤ 64.63526.8667 ± 2.7195(2.6851) 19.565 ≤ μ3. ≤ 34.169 c. L1 = Y1.. − Y2..

= −16.4666, L2 = Y1.. − Y3.. = 14.0000, L3 = Y2.. − Y3.. = 30.4666,s{Li} = 3.7973 (i = 1, 2, 3), q(.90; 3, 36) = 2.998, T = 2.120 −16.4666 ± 2.120(3.7973) −24.52 ≤ L1 ≤ −8.4214.0000 ± 2.120(3.7973) 5.95 ≤ L2 ≤ 22.0530.4666 ± 2.120(3.7973) 22.42 ≤ L3 ≤ 38.52 d. L = 12.4, s{L} = 6.5771, t(.975; 36) = 2.0281, 12.4 ± 2.0281(6.5771), −.94 ≤ L ≤ 25.74 26.12. a. βj(i) are independent N(0, σ2β); βj(i) are independent of εk(j). b. σ2β = 0, yes. c. H0: σ2β = 0, Ha: σ2β > 0. F* = 27.933/108.144 = .258, F(.90; 6, 36) = 1.94 . If F* ≤ 1.94 conclude H0, otherwise Ha. Conclude H0.

P-value = .95 d. H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F* = 3, 488.422/27.933 =124.885, F(.90; 2, 6) = 3.46. If F* ≤ 3.46 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ e. See Problem 26.11c. s{Li} = 1.9299 (i = 1, 2, 3), q(.90; 3, 6) = 3.56, T = 2.5173 −16.4666 ± 2.5173(1.9299) −21.32 ≤ L1 ≤ −11.6114.0000 ± 2.5173(1.9299) 9.14 ≤ L2 ≤ 18.8630.4666 ± 2.5173(1.9299) 25.61 ≤ L3 ≤ 35.32 f. H0: all σ2β(i) equal zero (i = 1, 2, 3), Ha: not all σ2β(i) equal zero. F* = 37.27/16.07 = 2.32, H(.95; 3, 2) = 87.5. If F* ≤ 87.5 conclude H0, otherwise Ha. Conclude H0. 26.13. a. αi are independent N(0, σ2α); βj(i) are independent N(0, σ2β); αi, βj(i), and εk(ij) are independent. b. σ2β = 0 c. σ2α = 230.699 c.

H0: σ2α = 0, Ha: σ2α > 0. F* = 3, 488.422/27.933 = 124.885, F(.99; 2, 6) = 10.9. If F* ≤ 10.9 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ 26-2 d. c1 = 1/15, c2 = −1/15, MS1 = 3488.422, MS2 = 27.933, df1 = 2, df2 = 6,F1 = F(.995; 2, ∞) = 5.30, F2 = F(.995; 6, ∞) = 3.09, F3 = F(.995; ∞, 2) = 200,F4 = F(.995; ∞, 6) = 8.88, F5 = F(.995; 2, 6) = 14.5, F6 = F(.995; 6, 2) = 199.01 = .8113, G2 = .6764, G3 = −1.2574, G4 = −93.0375, HL = 187.803, HU = 46, 279.30 −42.90 ≤ σ2 α ≤ 3316.0 26.17. a. eijk: i = 1 k j = 1 j = 2 j = 3 i = 2k j = 1 j = 2 j = 3 i = 3k j = 1 j = 2 j = 3 ... −.4000 .0333 −.36672 −.0000 .0333 −.33333 4.0000 −.3667 .3333 i = 3k j = 1 j = 2 j = 3 i 4k j = 1 j = 2 j = 3 ... −.4333 −.20002 −.2333 .0667 .3333 −.10003 −1.0000 i 3k j = 1 j = 2 j = 3 ... −.3667 −.20001 −.6333 .4333 .2000 .0333 −.4333 .4333 .1333 −.7667 −.0000 −.3000 i = 4k j = 1 j = 2 j = 3 .0667 −.3000 −.4333 .2000 .00003 −.3667 .3333 −.1000 r = .972 26.20. a.Source SS df MS Plants 343.1789 3 114.3930Leaves, within plants 187.4533 8 23.4317Observations, within leaves 3.0333 24 .1264Total 533.6655 35 b. H0: σ2 = 0, Ha: σ2 > 0.

F* = 114.3930/23.4317 = 4.88, F(.95; 3, 8) = 4.07. If F* ≤ 4.07 conclude H0, otherwise Ha. Conclude Ha. P-value = .03 c. H0: σ2β = 0, Ha: σ2β > 0. F* = 23.4317/.1264 = 185.38, F(.95; 8, 24) = 2.36. If F* ≤ 2.36 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ d. Y... = 14.26111, s{Y...} = 1.7826, t(.975; 3) = 3.182, 14.26111 ± 3.182(1.7826), 8.59 ≤ μ.. ≤ 19.93 e. σ2t = 10.1068, σ2 = 7.7684, σ2 = .1264 f. c1 = 1/12, c2 = −1/12, MS1 = 114.3930, MS2 = 23.4317, df1 = 3, df2 = 8, F1 = F(.95; 3, ∞) = 2.60, F2 = F(.95; 8, ∞) = 1.94, F3 = F(.95; ∞, 3) = 8.53, F4 = F(.95; ∞, 8) = 2.93, F5 = F(.95; 3, 8) = 4.07, F6 = F(.95; 8, 3) = 8.85, G1 = .6154, G2 = .4845, G3 = −.1409, G4 = −1.5134,HL = 9.042, HU = 95.446, 10.068−9.042, 10.068+95.446, 1.065 ≤ σ2 ≤ 105.51 26-3 26.4 Chapter 27 REPEATED MEASURES ANDRELATED DESIGNS 27.6. a. eij: i j = 1 j = 2 j = 3 1 −.2917 −.2417 1.5083 −.8458 6917 .15423 .6208 .0583 −.67924 .5542 .1917 −.74585 .5208 −.3417 −.17926 −1.4458 .3917 −.24587 .9875 −.7750 −.21258 −.4125 .0250 .3875 r = .992 d. H0: D = 0, Ha: D ≠ 0. RSTR.S = 9.5725, SSTR.S* = 2.9410, SSRem* =6.6315, F* = (2.9410/1) ÷ (6.6315/13) = 5.765, F (.99, 1, 13) = 9.07. If F* ≤ 9.07conclude H0, otherwise Ha. Conclude H0. P-value = .032 27.7. a.Source SS df MSStores 745.1850 7 106.4550Prices 67.4808 2 33.7404Error 9.5725 14 .68375Total 822.2383 23 b. H0: all τj equal zero (j = 1, 2, 3), Ha: not all τj equal zero. F* = 33.7404/.68375 =49.346, F (.95; 2, 14) = 3.739.

If F* ≤ 3.739 conclude H0, otherwise Ha. ConcludeHa. P-value = 0+ c. Y.1 = 55.4375, Y.2 = 53.6000, Y.3 = 51.3375, L1 = Y.1 − Y.2 = 1.8375, L2 = Y.1 − Y.3 = 4.1000, L3 = Y.2 − Y.3 = 2.2625, s{Li} = .413446 (i = 1, 2, 3),q(.95; 3, 14) = 3.70, T = 2.616 1.8375 ± 2.616(.413446) .756 ≤ L1 ≤ 2.9194.1000 ± 2.616(.413446) 3.018 ≤ L2 ≤ 5.1822.2625 ± 2.616(.413446) 1.181 ≤ L3 ≤ 3.344 27-1 d.

= 48.08 27.9. H0: all τj equal zero (j = 1, 2, 3), Ha: not all τj equal zero. MSTR = 8, MSTR.S = 0, F = R/8/0.

Note: Nonparametric F test results in SSTR.S = 0 and therefore should not be used. 27.13. a. eijk: k = 1 k = 2 k = 3 k = 4i 1 = 9.250 −8.750 1.250 −1.750i = 2 −11.750 −2.750 15.250 −.750i j = 1 i = 3 1 = 3.750 −5.250 5.750 −8.250 4 −5.250 16.750 −22.250 10.750i = 1 3.625 −3.125 −13.875 13.375 j = 2 i = 2 15.375 6.625 7.875 −29.875i = 3 −8.375 −3.125 −3.875 15.375i = 4 −10.625 −.375 9.875 1.125 r = .981 27.14. a. H0: σ2{ρi(1)} = σ2{ρi(2)}, Ha: σ2{ρi(1)} ≠ σ2{ρi(2)} , MS1 = 1, 478, 757.00, SSS(A2) = 1, 525, 262.25, H = (1, 525, 262.25/3) ÷ (1, 478, 757.00/3) = 1.03, H(.99; 2, 3) = 47.5. If H* ≤ 47.5 conclude H0, otherwise Ha. Conclude H0. H0: σ2{εi} = σ2{εi},Ha: σ2{εi} ≠ σ2{εi} (or σ2{ε}): SSB.S(A1) = 1, 653.00, SSB.S(A2) = 1, 172.25, H* = (1, 653/9) ÷ (1, 172.25/9) = 1.41, H(.99; 2, 9) = 6.54. If H* ≤ 6.54 conclude H0, otherwise Ha. Conclude H0. 27.15. a.Source SS df MS A (type display) 266, 085.1250 1 266, 085.1250S(A) 3, 004, 019.2500 6 500, 669.8750B (time) 53, 321.6250 3 17, 773.8750AB interactions 690.6250 3 230.2083Error 3, 825.2500 18 212.5139Total 3, 327, 941.8750 31 b. Y.11 = 681.500, Y.12 = 676.500, Y.13 = 671.500, Y.14 = 785.500, Y.21 = 508.500, Y.22 = 512.250, Y.23 = 496.000, Y.24 = 588.750 c.

H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = 230.2083/212.5139 = 1.08, F (.975; 3, 18) = 3.95. If F* ≤ 3.95 conclude H0, otherwise Ha. Conclude H0. P-value = .38 d. H0: α1 = α2 = 0, Ha: not both αi equal zero. F* = 266, 085.1250/500, 669.8750 = .53, F(.975; 1, 6) = 8.81. 27.2 If F* ≤ 8.81 conclude H0, otherwise Ha. Conclude H0. P-value = .49 H0: all βk equal zero (k = 1, . . . , 4), Ha: not all βk equal zero. F* = 17, 773.8750/212.5139 = 83.636, F (.975; 3, 18) = 3.95. If F* ≤ 3.95 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ e.

Y.1. = 708.750, Y.2. = 526.375, Y.1 = 595.000, Y.2 = 604.375, Y.3 = 588.750,Y.4 = 687.125, L1 = 182.375, L2 = −9.375, L3 = 15.625, L4 = −103.375,s{L1} = 250.1674, s{Li} = 7.2889 (i = 2, 3, 4), B1 = t(.9875; 6) = 2.969, Bi =t(.9875; 18) = 2.445 (i = 2, 3, 4) 182.375 ± 2.969(250.1674) −560.372 ≤ L1 ≤ 925.122−9.375 ± 2.445(7.2889) −27.196 ≤ L2 ≤ 8.44620.625 ± 2.445(7.2889) 2.804 ≤ L3 ≤ 38.446−103.375 ± 2.445(7.2889) −121.196 ≤ L4 ≤ −85.554 27.17.

a. eijk: j = 1 j = 2 k = 1 k = 1 i = 1 k 1 2 1 2i k = 1 −.045 .045 .045 −.0452 −.120 .120 .120 −.1203 .080 −.080 −.080 .0804 −.045 .045 .045 −.0455 .080 −.080 −.080 .0806 .055 −.055 −.0557 .030 −.030 −.030 .0308 −.045 .045 .045 −.0459 .055 −.055 −.055 .055 10 −.045 .045 .045 −.045r = .973 27.19. a.Source SS df MS Subjects 154.579 9 17.1754 3.025 1 3.0258 14.449 1 11.449AB .001 1 .001AS 2.035 9 .226BS 3.061 9 .3402ABS .169 9 .0187 Total 176.319 39 b. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = .001/.019 = .05, F(.995; 1, 9) = 13.6. If F* ≤ 13.6 conclude H0, otherwise Ha. Conclude H0. P-value = .82 c. H0: α1 = α2 = 0, Ha: not both αi equal zero. F* = 3.025/.226 = 13.38, F(.995; 1, 9) = 13.6. If F* ≤ 13.6 conclude H0, otherwise Ha. Conclude H0. P-value = .005 H0: β1 = β2 = 0, Ha: not both βj equal zero. F* = 11.449/.3402 = 33.65, F(.995; 1, 9) = 13.6. If F* ≤ 13.6 conclude H0, otherwise Ha. Conclude Ha. P-value = .001 L = .56, L2 = 1.08, L3 = −.52, L4 = 1.62, s{L1} = .0613 (i = 1, . . . , 4), B = t(.99375; 27) = 3.11 27.3 L1 = .56 ± 3.11(.0613) .75L1 ≤ .56 3.11(.0613) .75 L1 ≤ 1.27−.52 ± 3.11(.0613) −.71 ≤ L3 ≤ −.331.62 ± 3.11(.0613) 1.43 ≤ L4 ≤ 1.81 27-4 Chapter 28 BALANCED INCOMPLETEBLOCK, LATIN SQUARE, ANDRELATED DESIGNS 28.8. eij: i j = 1 j = 2 j = 3 j = 41 −.2083 .2083 −.58337 −.4583 −.2083 .45833 .3333 −.4583 .2083 .12504 .2083 −.2917 −.29175 −1.5417 .5833 −.0417 r = .996 28.9. a.

βj: 1 23.8333 −8.4167 12.3333 −5.6667 β1 = 13.3333 28.9. b. H0: all τj equal zero, Ha: not all τj equal zero. F* = .2000/.1083 = 1.85, F(.95; 3, 5) = 5.41. If F* ≤ 5.41 conclude H0, otherwise Ha. Conclude H0. P-value = .24 c.

H0: all τj equal zero (j = 1, . . . , 4), Ha: not all τj equal zero, τ1 = 12.79, τ2 = 9.66, τ3 = .0417, τ4 = −22.27 28.10. a. ... μ.. = 3.3967, r = .9934. ... b. H0: all τj equal zero (j = 1, . . . , 5), Ha: not all τj equal zero. F* = 2.7208/.1083 = 25.12, F(.99; 4, 8) = 7.01. If F* ≤ 7.01 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. ... L = ...

H0: ρ1 = ρ2 = 0, Ha: not both ρi equal zero. SSE(F) = 14.519, SSE(R) = 22788, F* = (21038.1/3) ÷ (1750.9/5) = 20.03, F(.95; 3, 5) = 5.41. If F* ≤ 5.41conclude H0, otherwise Ha. Conclude H0. P-value = .003 d. μ11 = 252.292, s2{μ.1} = s2{μ..} + s2{τ1} = 1.00833 = .28125. Ha. d. ... 45 ... Source SS df MS ... e.

H0: p1 = p2 = 0 ... ρ1 = 0. ... s2 ... ... Since the two ... 28.4.13 (See Problem 28.1 has n = 3, so we requirethat design 2 be repeated 10 times. Thus, n = 30, and nb = 40. 28.14. a.

eij: i j = 1 j = 2 j = 3 j = 41 −.1375 .0875 −.0125 .06252 −.0125 −.0125 .1625 −.13753 .1375 −.0875 −.0625 .01254 .0125 .0125 −.1625 .1375 r = .958 28.15. a.Source SS df MS Rows (Sales volume) 5.98187 3 1.99396Columns (locations) .12188 3 .04062Treatments (prices) 11.36888 3 3.78896Error .11875 6 .01979Total 17.5918 15 b. H0: all τk equal zero (k = 1, 2, 3, 4), Ha: not all τk equal zero. F* = 3.78896/.01979 = 191.49, F(.95; 3, 6) = 4.76. If F* ≤ 4.76 conclude H0, otherwise Ha. Conclude Ha.

P-value = 0+ c. Y..1 = 1.65, Y..2 = 1.125, Y..3 = 1.4125, Y..4 = 2.325, L1 = Y..2 − Y..1 = −.225, L2 = Y..3 − Y..2 = −.475, L3 = Y..4 − Y..3 = .925, s{Li} = .09947 (i = 1, 2, 3), B = t(.99167; 6) = 3.2875, −.225 ± 3.2875(.09947) −.552 ≤ L1 ≤ .1.−.475 ± 3.2875(.09947) −.802 ≤ L2 ≤ −.148.925 ± 3.2875(.09947) .598 ≤ L3 ≤ 1.252 d. H0: all τj equal zero, Ha: not all τj equal zero. ... .2583 ... L = ... 3.5 ... 3. −1.63 ... 1.0, 3 ... .89 ... 4 ...

a. Yijk = μ... + ρ1Xijk1 + ρ2Xijk2 + ρ3Xijk3 + κ1Xijk4 + κ2Xijk5 + κ3Xijk6 + τ1Xijk7 + τ2Xijk8 + τ3Xijk9 + εijk 28-2 Xijk1 = 1 if experiment unit from row blocking class 1 −1 if experimental unit from row blocking class 4 0 otherwise Xijk2 and Xijk3 are defined similarly Xijk4 = 1 if experimental unit from column blocking class 1 −1 if experimental unit from column blocking class 4 0 otherwise Xijk5 and Xijk6 are defined similarly Xijk7 = 1 if experimental unit received treatment 1 −1 if experimental unit received treatment 4 0 otherwise Xijk8 and Xijk9 are defined similarly b. Full model: Y = 2.05625 − .70625X1 − .45625X2 + .34375X3 + .14375X4 − .05625X5 − .00625X6 − .33125X7 − .15625X8 + .11875X9 SSE(F) = .1188 Reduced model: Y = 2.05625 − .70625X1 − .45625X2 + .34375X3 + .14375X4 − .05625X5 − .00625X6 SSE(R) = 12.2556 H0: all τk equal zero, Ha: not all τk equal zero. F* = (11.368/3) ÷ (.1188/6) = 19.138, F (.95; 3, 6) = 4.76. If F* ≤ 4.76 conclude H0, otherwise Ha. Conclude Ha. c. L = τ3 − (τ1 + τ2 + τ4)/3 = τ3 + τ1 + τ2 + τ1 + τ2 + τ3 = 4/3 τ3 ... s{L} = .07231 ... L = .0031 ... t(.975; 6) = 2.447, −.250 ± 2.447(.09930), −.493 ≤ L ≤ −.007 d.

(i) Full model: Y = 2.02917 − .67917X1 − .53750X2 + .30417X3 + .23750X4 − .04167X5 + .01250X6 − .29583X7 − .08750X8 + .10417X9, SSE(F) = .0483 Reduced model: Y = 2.05556 − .70556X1 − .45833X2 + .34444X3 + .14444X4 − .05556X5 − .00833X6 SSE(R) = 12.2556 H0: all τk equal zero, Ha: not all τk equal zero. F* = (12.2073/3) ÷ (.04833/5) = 421.1, F(.95; 3, 5) = 5.41. If F* ≤ 5.41 conclude H0, otherwise Ha. Conclude Ha. (ii) ... = −.29167, s{L} = .00191, s2{τ} = −.00191, s{L} = .0803, t(.975; 5) = 2.571, −.06667 ± 2.571(.0803), −.273 ≤ L ≤ .140 28-3 28-4 Chapter 29 EXPLORATORY EXPERIMENTS -TWO-LEVEL FACTORIAL ANDFRACTIONAL FACTORIAL DESIGNS 29.3. a.

Six factors, two levels, 64 trials b. No 29.6. a. σ2{b1} = σ2/nT = 52/64 = .391. Yes, yes b. z(.975) = 1.96, nT = [1.96(5)/(.5)]2 = 384.16, 384.16/64 = 6 replicates 29.7. a.

Yi = β0Xi0 + β1Xi1 + · · · + β5Xi5 + β12Xi12 + · · · + β45Xi45 + β123Xi123 + · · · + β345Xi345 + β1234Xi1234 + · · · + β2345Xi2345 + β12345Xi12345 + εi Coef. bq b0 6.853b1 1.606b2 −.099b3 1.258b4 −1.151b5 −1.338b12 −.033b13 .455 Coef. bq b14 −.239b15 .611b23 −.134b24 −.127b25 −.045b34 −.311b35 .912b45 −.198 Coef. bq b123 .070b124 .201b125 −.118b134 −.378b135 −.138b145 −.183b234 .233b235 .055 Coef. bq b245 .076b345 −.576b1234 .062b1235 .323b1245 .357b1345 −.122b2345 −.292b12345 .043 29.8. a. Yi = β0Xi0 + β1Xi1 + · · · + β5Xi5 + β12Xi12 + · · · + β45Xi45 + εi 29-1 Coef. bq P-valueb0 6.853 .000b1 1.606 .000b2 −.099 .689b3 1.258 .000b4 −1.151 .000b5 −1.338 .000b12 −.033 .892b13 .455 .080 Coef.

bq P-valueb14 −.239 .340b15 .611 .023b23 −.134 .589b24 −.127 .610b25 −.045 .855b34 −.311 .219b35 .912 .002b45 −.198 .426 b. H0: Normal, Ha: not normal. r = .983. If r ≥ .9656 conclude H0, otherwise Ha. Conclude H0. c. H0: βq = 0, Ha: βq ≠ 0, s{bq} = .2432. If P-value ≥ .0034 conclude H0, otherwise Ha. Active effects (see part a): β1, β3, β4, β5, β35 29.15. Defining relation: I = 123 = 245 = 1345 Confounding scheme: 0 = 123 = 245 = 13451 = 23 = 1245 = 3452 = 13 = 4 = 123453 = 12 = 1345 = 1234 = 25 = 1245 = 134 = 14 = 235 = 124 = 23 = 134 = 1235 = 234 = 15 = 1345 = 1234 = 25 = 1345 = 1234 = 25 = 1344 = 235 = 12 = 1345 = 1245 = 12345 = 3515 = 235 = 124 = 34 Resolution III, no 29.18. a. Defining relation: 0 = 1235 = 2346 = 1247 = 1456 = 3457 = 1367 = 2567, resolution IV, no b. Omitting four-factor and higher-order interactions: 1 = 235 = 247 = 456 = 3672 = 135 = 147 = 346 = 5673 = 125 = 246 = 137 = 145 = 236 = 176 = 5 = 123 = 146 = 247 = 6 = 234 = 145 = 2572 = 13 = 234 = 1245 = 5 = 3467 = 12 = 16 = 2345 = 1247 = 356 = 27 = 34 = 2626 = 34 = 57 = C, Yi = 6.669, 6.16 = 6.669 = −1 9.75 = 2000 (b) 18.1 = 33.1 = 1.4 = 24 = 45 = 1367 = 26 = 157 = 1.75 = ... 7 = ... 2 Yi ...

= β0 + β1Xi1 + · · · + β7Xi7 + β12Xi12 + β13Xi13 + β14Xi14 + β15Xi15 + β16Xi16 + β17Xi17 + β24Xi24 + β25Xi25 + β26Xi26 + εi Coef. bq Coef. bq b0 8.020b1 .127b2 .002b3 .021b4 −2.927 Coef. bq b5 .577b6 −.467b7 −.766b12 .351b13 −.066 Coef. bq b14 −.258b15 .318b16 .117b17 .012b24 −.162 c. b0 = 8.020 29.22. a. Yi = β0Xi0 + β1Xi1 + · · · + β7Xi7 + εi Coef. bq P-value Coef. bq P-value b0 −24 ... Coef. ... bq P-value −.006 .797b5 .5494 ... (b). ... b4 ... b5 ... −.6e .75 .31, 0 ... b6 ... −.7d ... Yi = ... c. H0: βq = 0, Ha: βq ≠ 0. If P-value ≥ .01 conclude H0, otherwise Ha. Active effects (see part a) = ... b .. d. H0: normal, Ha: not normal. r = .9936 ... ... 2.71 If r ≥ .929 conclude H0, otherwise Ha. Conclude H0. e. Factors ... and ... 29.25. a. Yi = β0 + β1Xi1 + β2Xi2 + β3Xi3 + β4Xi4 + β12Xi12 + · · · + β24Xi24 + β123Xi123 + ... Active effects (see part a) ... b. H0: βq = 0, Ha: βq ≠ 0. ... 1.7 ... = 0 to maximize extraction. 29.26. b. The seven block effects are confounded with the following interaction terms: β124,β136, β236, β245, β1234, β1256, β3456 No, no c. Yi = β0Xi0 + β1Xi1 + · · · + β6Xi6 + β12Xi12 + · · · + β56Xi56 + β123Xi123 + · · · + β456Xi456 + β1235Xi1235 + · · · + β2456Xi2456 + β12345Xi12345 + · · · + β23456Xi23456 + β123456Xi123456 + α1Z1 + · · · + α7Z7 + εi where Z1, . . . , Z7 are the block indicator variables. Coef. bq Coef. bq b0 63.922b1 2.984b2 2.922b3 .828b4 1.703b5 2.172b6 2.359b12 .094b13 −.266b14 −1.141b15 .891b16 .297b23 −.266b24 .984b25 −.422b26 −.203b34 .172b35 1.203b36 −.234b45 .891b46 −.234b56 −.109b123 −.047b125 −.234b126 .516b134 .797b135 −.234b136 −.234b145 .234b146 .641b156 −.828b234 .266b235 .828b236 .016b245 .172b246 .328b256 −.203b345 .547b346 .297b356 .422b456 −.109b1235 −.328b1236 −.297b1245 .578b1246 .047b1256 −.016b1345 .016b1346 .203b1356 .109b1456 −.359b2345 .109b2346 −.078b2356 .078b2456 .109b12345 .266b12346 −.172b12356 −.047b12456 .172b13456 −.172b23456 .172b123456 .172 Coef. ... bq ... .203 ... 1.5 ... −.703 .725b45 −.797 .172 ... .859 ... 1.797 .125 ... d. H0: normal, Ha: not normal. r = .989. If r ≥ .9812 conclude H0, otherwise Ha. Conclude H0. c. H0: βq = 0, Ha: βq ≠ 0 ... .4 ... s{bq} ...

s{αi} = .513 for block effects. s{bq} = .5719 for factoreffects. If P-value ≥ .01 conclude H0, otherwise Ha. Active effects (see part a):Block effects 1, 4, 7, all main effects 29.28. a. See Problem 29.27a for estimated factor and block effects.

(These do not changewith subset model.) b.

Maximum team effectiveness is accomplished by setting each factor at its highlevel. 29-4 c.

Yh = 82.297, s{pred} = 4.857, t(.975; 50) = 2.009, 82.297 ± 2.009(4.857), 72.54 ≤ Yh(new) ≤ 92.05 29.32. a.1 2 3 4 5 6 7 8 eijk −.0164 .0173 .0804 .1100 .0010 .0079 .0953 .1134 loge s2i −4.109 −4.058 −2.521 −2.207 −3.351 −2.176 b. loge s2i = −3.651 + .331Xi1 + .1337Xi2 − .427Xi3 − .275Xi4 − .209Xi12 + .240Xi13 + .477Xi14.Xi2 appears to be active. c. vi = .006819 (for i = 1, 2, 5, 6) vi = .09887 (for i = 3, 4, 7, 8) d. Yi = 7.5800 + .0772Xi1 e. From the location model: X1 = +1; from the dispersion model: X2 = −1 f. From dispersion model: s2 = exp(−3.651 + 1.337(−1)) = .006819, and a 97.5% P.I. is [exp(−6.16), exp(−3.82)],or (.00211, .0219). g. MSE = .006819 + (8 − 5)(.00788/2) = .00819 d. ... 29-2 ... .124 29-5 29-6 Chapter 30 RESPONSE SURFACEMETHODOLOGY 30.11.

b. Coef. bq P-valueb0 1.868b1 .190 .007b2 .195 .006b3 −.120 .039b12 .162 .020 Coef. bq P-valueb13 −.038 .471b23 −.062 .251b11 .228 .044b22 −.047 .602b33 .028 .757 b. H0: βq = 0, Ha: βq ≠ 0, s{bq} = .0431 (for linear effects), s{bq} = .0481(for interaction effects), s{bq} = .0849 (for quadratic effects).

If P-value ≥ .05conclude H0, otherwise Ha. Active effects (see part b): β1, β2, β3, β12, β11 b. Coef. bq b0 1.868b1 .190b2 .195 .b3 −.120 c.

bq b3 −.120b12 .162b11 .220 b. H0: Normal, Ha: not normal. r = .947. If r ≥ .938 conclude H0, otherwise Ha. Conclude H0. 30.14. a. 30-1 Design Matrix:X1 X2 −.707 −.707.707 −.707 −.707 .707.707 .707 −1 0 1 0 −10 10 00 00 00 00 00 00 00 0 Corner Points:X1 X2 −.707 −.707 −.707 .707 −.707 .707 .707 .707 −.707 −.707 .707 .707 .707 .707 b. X2 (C)X1 −1 .125 0 0 −.125 .125 0 0 −.125 .125 0 0 0 0 0 −.125 0 0 −.125 0 0 0 0 .125 0 0 0 0 0 .125 0 0 .125 0 0 0 0 0 0 0 0 0 0 0 0 130 L a. b. e. a = 2 (c) H0: p = 2.000 .12 a, γ = 0.2 = 1 .125 1 .1 ... 1 .0 .. 2 b. H0: ... 30.16. a. ... 0 .2 .. 1.4 ... 2.3 20 ... Solutions Manual to accompany Applied Linear Statistical Models Fifth Edition Michael H. KutnerEmory University Christopher J. NachtsheimUniversity of Minnesota John NeterUniversity of Georgia William LiUniversity of Minnesota 2005McGraw-Hill/IrwinChicago, IL Boston, MA PREFACE This Solutions Manual gives intermediate and final numerical results for all end-of-chapterProblems, Exercises, and Projects with computational elements contained in Applied LinearStatistical Models, 5th edition. This Solutions Manual also contains proofs for all Exercisesthat require derivations. No solutions are provided for the Case Studies. In presenting calculational results we frequently show, for ease in checking, more digitsthan are significant for the original data. Students and other users may obtain slightly different answers than those presented here, because of different rounding procedures. When a problem requires a percentile (e.g. of the t or F distributions) not included in the Appendix B Tables, users may either interpolate in the table or employ an available computer program for finding the needed value. Again, slightly different values may be obtained than the ones shown here. We have included many more Problems, Exercises, and Projects at the ends of chapters than can be used in a term, in order to provide choice and flexibility to instructors in assigning problem material. For all major topics, three or more problem settings are presented, and theinstructor can select different ones from term to term. Another option is to supply studentswith a computer printout for one of the problem settings for study and class discussion and toselect one or more of the other problem settings for individual computation and solution. Bydrawing on the basic numerical results in this Manual, the instructor also can easily designadditional questions to supplement those given in the text for a given problem setting. The data sets for all Problems, Exercises, Projects and Case Studies are contained in the compact disk provided with the text to facilitate data entry.

It is expected that the studentwill use a computer or have access to computer output for all but the simplest data sets,where use of a basic calculator would be adequate.

For most students, hands-on experiencein obtaining the computations by computer will be an important part of the educationalexperience in the course. While we have checked the solutions very carefully, it is possible that some errors arestill present. We would be most grateful to have any errors called to our attention. Erratacan be reported via the website for the book: . Weacknowledge with thanks the assistance of Lexin Li and Yingwen Dong in the checking ofChapters 1-14 of this manual. We, of course, are responsible for any errors or omissions thatremain. Michael H.

KutnerChristopher J. Nachtsheim John NeterWilliam Li i ii Contents 1 LINEAR REGRESSION WITH ONE PREDICTOR VARIABLE 1-1 2 INFERENCES IN REGRESSION AND CORRELATION ANALYSIS 2-1 3 DIAGNOSTICS AND REMEDIAL MEASURES 3-1 4 SIMULTANEOUS INFERENCES AND OTHER TOPICS IN REGRES-SION ANALYSIS 4-1 5 MATRIX APPROACH TO SIMPLE LINEAR REGRESSION ANALYSIS 5-1 6 MULTIPLE REGRESSION – I 6-1 7 MULTIPLE REGRESSION – II 7-1 8 MODELS FOR QUANTITATIVE AND QUALITATIVE PREDICTORS 8-1 9 BUILDING THE REGRESSION MODEL I: MODEL SELECTION ANDVALIDATION 9-1 10 BUILDING THE REGRESSION MODEL II: DIAGNOSTICS 10-1 11 BUILDING THE REGRESSION MODEL III: REMEDIAL MEASURES11-1 12 AUTOCORRELATION IN TIME SERIES DATA 12-1 13 INTRODUCTION TO NONLINEAR REGRESSION AND NEURAL NET-WORKS 13-1 14 LOGISTIC REGRESSION, POISSON REGRESSION,AND GENERALIZED LINEAR MODELS 14-1 15 INTRODUCTION TO THE DESIGN OF EXPERIMENTAL AND OB-SERVATIONAL STUDIES 15-1 16 SINGLE-FACTOR STUDIES 16-1 17 ANALYSIS OF FACTOR LEVEL MEANS 17-1 iii 18 ANOVA DIAGNOSTICS AND REMEDIAL MEASURES 18-1 19 TWO-FACTOR STUDIES – ONE CASE PER TREATMENT 20-1 21 RANDOMIZED COMPLETE BLOCK DESIGNS 21-1 22 ANALYSIS OF COVARIANCE 22-1 23 TWO-FACTOR STUDIES WITH UNEQUAL SAMPLE SIZES 23-1 24 MULTIFACTOR STUDIES 24-1 25 RANDOM AND MIXED EFFECTS MODELS 25-1 26 NESTED DE-SIGNS, SUBSAMPLING, AND PARTIALLY NESTED DESIGNS 26-1 27 REPEATED MEASURES AND RELATED DESIGNS 27-1 28 BALANCED INCOMPLETE BLOCK, LATIN SQUARE, AND RELATEDDESIGNS 28-1 29 EXPLORATORY EXPERIMENTS – TWO-LEVEL FACTORIAL AND FRACTIONAL FACTORIAL DESIGNS 29-1 30 RESPONSE SURFACE METHODOLOGY 30-1 Appendix D: RULES FOR DEVELOPING ANOVA MODELS AND TABLESFOR BALANCED DESIGNS D.1 iv Chapter 1 LINEAR REGRESSION WITH ONEPREDICTOR VARIABLE 1.1. No 1.2. Y = 300 + 2X, functional 1.5. No 1.7. a. No b. Yes, .68 1.8. Yes, no 1.10. No 1.12. a.

Observational 1.13. a.

Observational 1.18. No 1.19. a. β0 = 2.11405, β1 = 0.03883, Y = 2.11405 + .03883X c. Yh = 3.27895 d. β1 = 0.03883 1.20. a. Y = −0.5802 + 15.0352X d. Yh = 74.5958 1.21. a.

Y = 10.20 + 4.00X b. Yh = 14.2 c. 4.0 d. (X, Y) = (1, 14.2) 1.22. a. Y = 168.600000 + 2.034375X b. Yh = 249.975 c. β1 = 2.034375 1.23. a.i: 1 2 . . . 19 120 ei: 0.9676 1.2274 . . . −0.8753 −0.2532 Yes b. MSE = 0.388,√ MSE = 0.623, grade points 1.24. a.i: 1 2 . . . 44 45 ei: −9.4903 0.4392 . . . 1.4392 2.4039∑ e2i = 3416.377 Min Q = ∑ e2i b. MSE = 79.45063,√ MSE = 8.913508, minutes 1.25. a. e1 = 1.8000 b.∑ e2i = 17.6000, MSE = 2.2000, σ2 1.26. a.i: 1 2 3 4 5 6ei: −2.150 3.850 −5.150 −1.150 .575 2.575 i: 7 8 9 10 11 12ei: −2.425 5.575 3.300 1.300 −3.700 i: 13 14 15 16ei: .025 −1.975 3.025 −3.975 Yes b. MSE = 10.459,√ MSE = 3.234, Brinell units 1.27. a. Y = 156.35 − 1.19X b. (1) b1 = −1.19, (2) Yh = 84.95, (3) e8 = 4.4433, (4) MSE = 66.8 1.28. a. Y = 20517.6 − 170.575X b. (1) b1 = −170.575, (2) Yh = 6871.6, (3) e1 = 1401.566, (4) MSE = 5552112 1.31. No, no 1.32. Solving (1.9a) and (1.9b) for b0 and equating the results: ∑Yi − b1 ∑Xi n = ∑XiYi − b1 ∑X2i ∑Xi and then solving for b1 yields: b1 = n∑XiYi − ∑Xi ∑Yi n∑X2i − (∑Xi)2 = ∑XiYi − ∑Xi ∑Yi n ∑X2i − (∑Xi)2 n 1-1 1.33. Q = ∑(Yi − β0)2 dQ dβ0 = −2∑(Yi − β0) Setting the derivative equal to zero, simplifying, and substituting the least squares estimator b0 yields: ∑(Yi − b0) = 0 or b0 = Y 1.34. E{b0} = E{Y} = 1 n ∑ E{Yi} = 1 n ∑ β0 = β0 1.35. From the first normal equation (1.9a): ∑Yi = nb0 + b1 ∑Xi = ∑(b0 + b1Xi) from (1.13) = ∑Yi 1.36. ∑ Yiei = ∑(b0 + b1Xi)ei = b0 ∑ ei + b1 ∑ Xiei = 0 because ∑ ei = 0 from (1.17) and∑Xiei = 0 from (1.19). 1.38. (1) 76, 60.0, 1 (2) Applying (1.10a) and (1.10b) with the six original points yields the same results. 1.39. a. Applying (1.10a) and (1.10b) to (5, Y1), (10, Y2) and (15, Y3), we obtain: b1 = Y3 − Y1 10 b0 = 4Y1 + Y2 − 2Y3 3 Using (1.10a) and (1.10b) with the six original points yields the same results. b. Yes 1.40. No 1.41. a.

Q = ∑(Yi − β1Xi)2 dQ dβ1 = −2∑ Xi(Yi − β1Xi) Setting the derivative equal to zero, simplifying, and substituting the least squares estimator b1 yields: b1 = ∑YiXi∑X2i b. L = ∏ i=1 1 (2πσ2)1/2exp [− 1 2σ2(Yi − β1Xi)2] 1-3 It is more convenient to work with loge L : loge L = −n 2loge(2πσ2) − 1 2σ2 ∑(Yi − β1Xi)2 d loge L dβ1 = 1 σ2 ∑ Xi(Yi − β1Xi) Setting the derivative equal to zero, simplifying, and substituting the maximumlikelihood estimator b1 yields: ∑ Xi(Yi − b1Xi) = 0 or b1 = ∑YiXi∑X2i Yes c. E{b1} = E (∑YiXi∑X2i) = 1∑X2i E{∑YiXi} = 1∑X2i ∑XiE{Yi} = 1∑X2i ∑Xi(β1Xi) = β1 1-2 1.42. a. L(17) = 9.45× 10−30, L(18) = 2.65× 10−7, L(19) = 3.05× 10−37 b1 = 18 c.

b1 = 17.928, yes d. Yes 1.43. a. Total population: Y = −110.635 + 0.0027954X Number of hospital beds: Y = −95.9322 + 0.743116X Total personal income: Y = −48.3948 + .131701X c. Total population: MSE = 372, 203.5 Number of hospital beds: MSE = 310, 191.9 Total personal income: MSE = 324, 539.4 1.44. a. Region 1: Y = −1723.0 + 480.0X Region 2: Y = 916.4 + 299.3X Region 3: Y = 401.56 + 272.2X Region 4: Y = 209.9 + 418.7X c. Region 1: MSE = 64, 444, 465 Region 2: MSE = 141, 479, 673 Region 3: MSE = 50, 242, 464 Region 4: MSE = 147, 585, 105, 1.45. a.

Infection risk: Y = 6.3368 + .7604X Facilities: Y = 7.7188 + .0447X 1-4 X-ray: Y = 6.5664 + .0378X c. Infection risk: MSE = 2.638 Facilities: MSE = 3.221 X-ray: MSE = 3.147 1.46. a. Region 1: Y = 4.5379 + 1.3478X Region 2: Y = 7.5605 + .4832X Region 3: Y = 7.1293 + .5251X Region 4: Y = 8.0381 + .0173X c. Region 1: MSE = 4.353 Region 2: MSE = 1.038 Region 3: MSE = .940 Region 4: MSE = 1.078 1.47. a. L(β0, β1) = 6∏ i=1 1√32π exp [− 1 32(Yi − β0 − β1Xi)2] b0 = 1.5, β1 = 1.8, L(β0, β1) = 2.97 × 10−7 b. L(3.0, 1.0) = 1.3 ... Chapter 2 INFERENCES IN REGRESSION AND CORRELATION ANALYSIS 2.1. a. Yes, α = .05 2.2. a.

H0: β1 ≤ 0, Ha: β1 > 0. 2.4. a. s{b1} = .0049, t(.995; 118) = 2.618, .0388 ± 2.618(.0049), .0259 ≤ β1 ≤ .0517 b. H0: β1 = 0, Ha: β1 ≠ 0. t* = 3.0388/.0049 = 7.923 6.49. If |t*| ≤ 2.618 conclude H0, otherwise Ha. Conclude Ha. P-value= 0+ c. 0 2.5. a. t(.95; 43) = 1.6811, 15.0352 ± 1.6811(.4831), 14.2231 ≤ β1 ≤ 15.8473 b. H0: β1 = 0, Ha: β1 ≠ 0.

t* = 15.0352/.4831 = 31.122.

If |t*| ≤ 1.681 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. Yes d. H0: β1 ≤ 14, Ha: β1 > 14. t* = (15.0352 − 14)/.4831 = 2.1428. If t* ≤ 1.681conclude H0, otherwise Ha. Conclude Ha. P-value = .0189 2.6. a. t(.975; 8) = 2.306, b1 = 4.0, s{b1} = .469, 4.0± 2.306(.469), 2.918 ≤ β1 ≤ 5.082 b. H0: β1 = 0, Ha: β1 ≠ 0. t* = (4.0 − 0)/.469 = 8.529. If |t*| ≤ 2.306 conclude H0, otherwise Ha. Conclude Ha. P-value = .00003 c. b0 = 10.20, s{b0} = .663, 10.20 ± 2.306(.663), 8.671 ≤ β0 ≤ 11.729 d. H0: β0 ≤ 9, Ha: β0 > 9. t* = (10.20 − 9)/.663 = 1.810. If t* ≤ 2.306 conclude H0, otherwise Ha. Conclude H0. P-value = .053 e. H0: β1 = 0: δ = |2 − 0|/.5 = 4, power = .93 H0: β0 ≤ 9: δ = |11 − 9|/.75 = 2.67, power = .78 2.7. a. t(.995; 14) = 2.977, s{b1} = .0904, 2.0344± 2.977(.0904), 1.765 ≤ β1 ≤ 2.304 b. H0: β1 = 2, Ha: β1 ≠ 2. t* = (2.0344 − 2)/.0904 = .381. If |t*| ≤ 2.977 concludeH0, otherwise Ha. Conclude H0. P-value = .71 c. δ = |.3|/.1 = 3, power = .50 2.8. a. H0: β1 = 3.0, Ha: β1 ≠ 3.0. t* = (3.57 − 3.0)/.3470 = 1.643, t(.975; 23) = 2.069. If |t*| ≤ 2.069 conclude H0, otherwise Ha. Conclude H0. b. δ = |.5|/.35 = 1.43, power = .30 (by linear interpolation) 2.10. a. Prediction b. Mean response c.

Prediction 2.12. No, no 2.13. a. Yh = 3.2012, s{Yh} = .0706, t(.975; 118) = 1.9803, 3.2012 ± 1.9803(.0706), 3.0614 ≤ E{Yh} ≤ 3.3410 b. s{pred} = .6271, 3.2012 ± 1.9803(.6271), 1.9594 ≤ Yh(new) ≤ 4.4430 c. Yes, yes d. W2 = 2F(.95; 2, 118) = 2(3.0731) = 6.1462, W = 2.4792, 3.2012 ± 2.4792(.0706), 3.0262 ≤ β0 + β1X ≤ 3.3762, yes, yes 2.14. a. Yh = 89.6313, s{Yh} = 1.3964, t(.95; 43) = 1.6811, 89.6313 ± 1.6811(1.3964), 87.2838 ≤ E{Yh} ≤ 91.9788 b. s{pred} = 9.0222, 89.6313 ± 1.6811(9.0222), 74.4641 ≤ Yh(new) ≤ 104.7985, yes, yes 2.2-2 c. 87.2838/6 = 14.5473, 91.9788/6 = 15.3298, 14.5473 ≤ Mean time per machine ≤ 15.3298 d. W2 = 2F(.90; 2, 43) = 2(2.4304) = 4.8608, W = 2.2047, 89.6313±2.2047(1.3964), 86.5527 ≤ β0 + β1Xh ≤ 92.7099, yes, yes 2.15. a.

Xh = 2: Yh = 18.2, s{Yh} = .663, t(.995; 8) = 3.355, 18.2 ± 3.355(.663), 15.976 ≤ E{Yh} ≤ 20.424 Xh = 4: Yh = 26.2, s{Yh} = 1.483, 26.2± 3.355(1.483), 21.225 ≤ E{Yh} ≤ 31.175 b. s{pred} = 1.625, 18.2 ± 3.355(1.625), 12.748 ≤ Yh(new) ≤ 23.652 c. s{predmean} = 1.083, 18.2 ± 3.355(1.083), 14.567 ≤ Yh(new) ≤ 21.833, 44 = 3(14.567) ≤ Total number of broken ampules ≤ 3(21.833) = 65.5 d. W2 = 2F(.99; 2, 8) = 2(8.65) = 17.30, W = 4.159 Xh = 2: 18.2 ± 4.159(.663), 15.443 ≤ β0 + β1Xh ≤ 20.957 Xh = 4: 26.2 ± 4.159(1.483), 20.032 ≤ β0 + β1Xh ≤ 32.368 yes, yes 2.16. a. Yh = 229.631, s{Yh} = .8285, t(.99; 14) = 2.624, 229.631±2.624(.8285), 227.457 ≤ E{Yh} ≤ 231.805 b. s{pred} = 3.338, 229.631 ± 2.624(3.338), 220.872 ≤ Yh(new) ≤ 238.390 c. s{predmean} = 1.316, 229.631 ± 2.624(1.316), 226.178 ≤ Yh(new) ≤ 233.084 d. Yes, yes e.

W2 = 2F(.98; 2, 14) = 2(5.241) = 10.482, W = 3.238, 229.631 ± 3.238(.8285), 226.948 ≤ β0 + β1Xh ≤ 232.314, yes, yes 2.17. Greater, H0: β1 = 0 2.20. No 2.22. Yes, yes 2.23. a. Source SS df MSRegression 3.58785 1 3.58785Error 45.8176 118 0.388285Total 49.40545 119 b. σ2 + β21 ∑(Xi − X)2, σ2, when β1 = 0 c. H0: β1 = 0, Ha: β1 ≠ 0. F* = 3.58785/0.388285 = 9.24, F(.99; 1, 118) = 6.855. If F* ≤ 6.855 conclude H0, otherwise Ha. Conclude Ha. d. SSR = 3.58785, 7.26% or 0.0726, coefficient of determination e. +0.2695 f. R2 2.24. a.

Source SS df MS Regression 76,960.4 1 76,960.4Error 3,416.38 43 79.4506Total 80,376.78 44 Correction for mean 261,747.2 Total, uncorrected 342,124 b. H0: β1 = 0, Ha: β1 ≠ 0. F* = 76, 960.4/79.4506 = 968.66, F(.90; 1, 43) = 2.826. If F* ≤ 2.826 conclude H0, otherwise Ha. Conclude Ha. c. 95.75% or 0.9575, coefficient of determination d.

+.9785 e. R2 2-3 2.25. a. Source SS df MSRegression 160.00 1 160.00Error 17.60 8 2.20Total 177.60 9 b. H0: β1 = 0, Ha: β1 ≠ 0. F* = 160.00/2.20 = 72.727, F(.95; 1, 8) = 5.32. If F* ≤ 5.32 conclude H0, otherwise Ha. Conclude Ha. c. t* = (4.00 − 0)/.469 = 8.528, (t*)2 = (8.528)2 = 72.727 = F* d. R2 = .9009, r = .9492. 90.09% 2.26. a. Source SS df MSRegression 5,297.5125 1 5,297.5125Error 146.4250 14 10.4589Total 5,443.9375 15 b. H0: β1 = 0, Ha: β1 ≠ 0. F* = 5, 297.5125/10.4589 = 506.51, F(.99; 1, 14) = 8.86.If F* ≤ 8.86 conclude H0, otherwise Ha. Conclude Ha. c. i: 1 2 3 4 5 6 7 8 Yi − Y: −24.150 −24.150 −24.150 −24.150 −8.150 −8.150 −8.150 −8.150 Yi − Yi: −2.150 3.850 −5.150 −1.150 .575 2.575 −2.425 5.575 Yi − Y: −22.000 −28.000 −19.000 −23.000 −8.725 −10.725 −5.725 −13.725 i: 9 10 11 12 13 14 15 16 Yi − Y: 8.075 8.075 8.075 8.075 24.425 24.425 24.425 24.425

Yi − Yi: 3.300 1.300 −3.700 −.900 .025 −1.975 3.025 −3.975 Yi − Y: −24.4125 24.425 24.425 24.425 d. R2 = .9731, r = .9865 2.27.

a. H0: β1 ≥ 0, Ha: β1 < 0. s{b1} = 0.090197, t* = (−1.19 − 0)/.090197 = −13.193, t(.05; 58) = −1.67155. If t* ≥ −1.67155 conclude H0, otherwise Ha. Conclude Ha.P-value = 0+ c. t(.975; 58) = 2.00172, −1.19 ± 2.00172(.090197), −1.3705 ≤ β1 ≤ −1.0095 2.28. a. Yh = 84.9468, s{Yh} = 1.05515, t(.975; 58) = 2.00172, 84.9468± 2.00172(1.05515), 82.835 ≤ E{Yh} ≤ 87.059 b.

s{Yh(new)} = 8.24101, 84.9468± 2.00172(8.24101), 68.451 ≤ Yh(new) ≤ 101.443 c. W2 = 2F (.95; 2, 58) = 2(3.15593) = 6.31186, W = 2.512342,84.9468±2.512342(1.05515), 82.296 ≤ β0 + β1Xh ≤ 87.598, yes, yes 2.29. a. 2-4 i: 1 2 . . . 59 60 Yi − Yi: 0.823243 −1.55675 .

. −0.666887 8.09309 Yi − Y : 20.2101 22.5901 . . . −14.2998 −19.0598 b. Source SS df MSRegression 11,627.5 1 11,627.5Error 3,874.45 58 66.8008Total 15,501.95 59 c. H0: β1 = 0, Ha: β1 ≠ 0. F* = 11, 627.5/66.8008 = 174.0623,F (.90; 1, 58) = 2.79409. If F* ≤ 2.79409 conclude H0, otherwise Ha. Conclude Ha. d. 24.993% or .24993 e. R2 = 0.750067, r = −0.866064 2.30. a. H0: β1 = 0, Ha: β1 ≠ 0. s{b1} = 41.5743, t* = (−170.575 − 0)/41.5743 = −4.1029, t(.995; 82) = 2.63712. If |t*| ≤ 2.63712 conclude H0, otherwise Ha. Conclude Ha.

P-value = 0.0001 b. −170.575 ± 2.63712(41.5743), −280.2114 ≤ β1 ≤ −60.9386 2.31. a.

Source SS df MSRegression 93,462, 942 1 93,462, 942Error 455,273, 165 82 5,552,112Total 548,736,107 83 b. H0: β1 = 0, Ha: β1 ≠ 0. F* = 93, 462, 942/5, 552, 112 = 16.8338, F(.99; 1, 82) = 6.9544. If F* ≤ 6.9544 conclude H0, otherwise Ha. Conclude Ha. (t*)2 = (−4.102897)2 = 16.8338 = F*. [t(.995; 82)]2 = (2.63712)2 = 6.9544 = F(.99; 1, 82). Yes. c. SSR = 93, 462, 942, 17.03% or 0.1703 d. −0.4127 2.32. a. Full: Yi = β0 + β1Xi + εi, reduced: Yi = β0 + εi b. (1) SSE(F) = 455, 273, 165, (2) SSE(R) = 548, 736, 107, (3) dfF = 82, (4) dfR = 83, (5) F* = [(548, 736, 107 − 455, 273, 165)/1] ÷ (455, 273, 165/82) = 16.83376, (6) If F* ≤ F(.99; 1, 82) = 6.9544 conclude H0, otherwise Ha. c. Yes 2.33. a. H0: β0 = 7.5, Ha: β0 ≠ 7.5. b. Full: Yi = β0 + β1Xi + εi, reduced: Yi − 7.5 = β1Xi + εi c. Yes, dfR − dfF = (n − 1) − (n − 2) = 1 2.36 2-5 2.38. No 2.39. a. Normal, mean μ1 = 50, standard deviation σ1 = 3 b. Normal, mean E{Y2|Y1 = 55} = 105.33, standard deviation σ2|1 = 2.40 c. Normal, mean E{Y1|Y2 = 95} = 47, standard deviation σ1|2 = 1.80 2.40. (1) No, (2) No, (3) Yes 2.41. No 2.42. b. .95285, ρ12 c. H0: ρ12 = 0, Ha: ρ12 ≠ 0. t* = (.95285√13)/√1 − (.95285)2 = 11.32194, t(.995; 13) = 3.012. If |t*| ≤ 3.012 conclude H0, otherwise Ha. Conclude Ha. d. No 2.43. a. H0: ρ12 = 0, Ha: ρ12 ≠ 0. t* = (.61√82)/√1 − (.61)2 = 6.9709, t(.975; 82) = 1.993. If |t*| ≤ 1.993 conclude H0, otherwise Ha. Conclude Ha. b. z′ = .70892, σ{z′} = .1111, z(.975) = 1.960, .70892 ± 1.960(.1111), .49116 ≤ ζ ≤ .92668, .455 ≤ ρ12 ≤ .729 c. .207 ≤ ρ212 ≤ .531 2.44. a. H0: ρ12 = 0, Ha: ρ12 ≠ 0. t* = (.87√101)/√1 − (.87)2 = 17.73321, t(.95; 101) = 1.663. If |t*| ≤ 1.663 conclude H0, otherwise Ha. Conclude Ha. b. z′ = 1.33308, σ{z′} = .1, z(.95) = 1.645, 1.33308 ± 1.645(.1), 1.16858 ≤ ζ ≤ 1.49758, .824 ≤ ρ12 ≤ .905 c. .679 ≤ ρ212 ≤ .819 2.45. a. z′ = 1.18814, σ{z′} = .0833, z(.995) = 2.576, 1.18814 ± 2.576(.0833), .97356 ≤ ζ ≤ 1.40272, .750 ≤ ρ12 ≤ .886 b.

.563 ≤ ρ212 ≤ .785 2.46. a. 0.9454874 b. H0 : ρ12 = 0, Ha : ρ12 ≠ 0. t* = (0.9454874 √13)/√ 1 − (0.9454874)2 = 10.46803, t(0.995, 13) = 3.012276.

If |t*| ≤ 3.012276, conclude H0, otherwise, conclude Ha. Conclude Ha. c. −0.866064 2.47. a. −0.866064, b. H0 : ρ12 = 0, Ha : ρ12 ≠ 0. t* = (−0.866064√58)/√ 1 − (−0.866064)2 = −13.19326, t(.975, 58) = 2.00172. If |t*| ≤ 2.00172 conclude H0, otherwise, conclude Ha. Conclude Ha. 2-6 c. −0.8657217 d. There is no association between X and YHa : There is an association between X and Y t* = −0.8657217 √58√ 1 − (−0.8657217)2 = −13.17243. t(0.975, 58) = 2.001717. If |t*| ≤ 2.001717, conclude H0, otherwise, conclude Ha. Conclude Ha. 2.48. a. −0.4127033 b. H0 : ρ12 = 0, Ha : ρ12 ≠ 0. t* = (−0.4127033√82)/√ 1 − (−0.4127033)2 = −4.102897, t(.995, 82) = 2.637123. If |t*| ≤ 2.637123 conclude H0, otherwise, conclude Ha. Conclude Ha. c. −0.4259324 d. H0 : There is no association between X and YHa : There is an association between X and Y t* = −0.4259324 √82√ 1 − (−0.4259324)2 = −4.263013. t(0.995, 82) = 2.637123. If |t*| ≤ 2.637123, conclude H0, otherwise, conclude Ha. Conclude Ha. 2.50. ∑ kiXi = ∑ (Xi − X)Xi∑(Xi − X)2 = ∑ (Xi − X)2∑(Xi − X)2 = 1 because ∑ (Xi − X)X = 0 2.51. E{b0} = E{Y − b1X} = 1 n ∑E{Yi} − XE{b1} = 1 n ∑(β0 + β1Xi) − Xβ1 = β0 + β1X − Xβ1 = β0 2.52.

σ2{b0} = σ2{Y} + X2σ2{b1} − 2Xσ{Y , b1} = σ2 n + X2 σ2∑(Xi − X)2 − 0 = σ2 [1 n + X2∑(Xi − X)2] 2.53. a. L = n∏[i=1 1√2πσ2 exp[− 1 2σ2(Yi − β0 − β1Xi)2]g(Xi) 2-7 b. Maximum likelihood estimators can be found more easily by working with loge L: loge L = −n 2loge(2πσ2) − 1 2σ2 ∑(Yi − β0 − β1Xi)2 + ∑ loge g(Xi) ∂ loge L ∂β0 = 1 σ2 ∑(Yi − β0 − β1Xi) ∂ loge L ∂β1 = 1 σ2 ∑ Xi(Yi − β0 − β1Xi) ∂ loge L ∂σ2 = −n 2σ2 + 1 2σ4 ∑(Yi − β0 − β1Xi)2 Setting each derivative equal to zero, simplifying, and substituting the maximum likelihood estimators b0, b1, and σ2 yields: (1) ∑Yi − nb0 − b1 ∑Xi = 0 (2) ∑XiYi − b0 ∑Xi − b1 ∑X2i = 0 (3) ∑(Yi − b0 − b1Xi)2 n = σ2 Equations (1) and (2) are the same as the least squares normal equations (1.9), hence the maximum likelihood estimators b0 and b1 are the same as those in (1.27). 2.54. Yes, no 2.55. SSR = ∑(Yi − Y)2 = ∑[(b0 + b1Xi) − Y]2 = ∑[(Y − b1X + b1Xi) − Y]2 = b21 ∑(Xi − X)2 2.56. a. E{MSR} = 1, 026.36, E{MSE} = .36 b. E{MSR} = 90.36, E{MSE} = .36 2.57. a. Yi − 5Xi = β0 + εi, n − 1 b. Yi − 2 − 5Xi = εi, n 2.58. If ρ12 = 0, (2.74) becomes: f(Y1|Y2) = 1√2πσ1 exp [−1 2 (Y1 − μ1σ1)2] = f1(Y1) 2.59. a. L = n∏ i=1 1 2πσ1σ2 √1 − ρ212 × exp { − 1 2(1 − ρ212) [(Yi1 − μ1 σ1)2 − 2ρ12(Yi1 − μ1 σ1)(Yi2 − μ2 σ2) + (Yi2 − μ2 σ2)2]} 2-8 It is easier to work with loge L: loge L = −n loge 2π − n 2 loge σ21 − n 2 loge σ22 − n 2 loge(1 − ρ212) − 1 2(1 − ρ212) ∑ [(Yi1 − μ1 σ1)2 − 2ρ12 (Yi1 − μ1 σ1)(Yi2 − μ2 σ2) + (Yi2 − μ2 σ2)2] ∂ loge L ∂μ1 = 1 2(1 − ρ212) ∑[2(Yi1 − μ1) σ21 − 2ρ12 (Yi2 − μ2) σ1σ2] ∂ loge L ∂μ2 = 1 2(1 − ρ212) ∑ [2(Yi2 − μ2) σ22 − 2ρ12 (Yi1 − μ1) σ1σ2] ∂ loge L ∂σ21 = −n 2σ21 + 1 2(1 − ρ212) ∑[(Yi1 − μ1)2 σ41 − ρ12 (Yi1 − μ1)(Yi2 − μ2) σ31σ2] ∂ loge L ∂σ22 = −n 2σ22 + 1 2(1 − ρ212) ∑[(Yi2 − μ2)2 σ42 − ρ12 (Yi1 − μ1)(Yi2 − μ2) σ1σ32] ∂ loge L ∂ρ12 = nρ12 1 − ρ212 + 1 1 − ρ212 ∑(Yi1 − μ1 σ1)(Yi2 − μ2 σ2) − ρ12 (1 − ρ212)2 ∑[(Yi1 − μ1 σ1)2 − 2ρ12 (Yi1 − μ1 σ1)(Yi2 − μ2 σ2) + (Yi2 − μ2 σ2)2] Setting the derivatives equal to zero, simplifying, and substituting the maximumlikelihood estimators yields: (1) μ1 = ∑Yi1n = Y1 (2) μ2 = ∑Yi2n = Y2 (3) σ21 = ∑(Yi1 − Y1)2n (4) σ22 = ∑(Yi2 − Y2)2n (5) ρ12 = ∑(Yi1 − Y1)(Yi2 − Y2)[∑(Yi1 − Y1)2]1/2[∑(Yi2 − Y2)2]1/2 b. μ1|2 = μ1 − μ2 ρ12 σ1 σ2 , β12 = ρ12 σ1 σ2 , σ1|2 = σ1 √1 − ρ212 and then β12 = σ1 σ2 ρ12 Using equations (1) - (5) and letting ... = ∑(Xi − X)(Yi − Y) ... The equivalence is shown by letting Yi1 and Yi2 in part (a) be Yi and Xi, respectively. 2.60. Using regression notation and letting ∑(Xi − X)2 = ∑ x2i, ∑(Yi − Y)2 = ∑ y2i, ∑(Xi − X)(Yi − Y) = ∑ xiyi, we have r212 = (∑ xiyi)2/(∑ x2i ∑ y2i) and b1 = ∑ xiyi/∑ x2i ... Hence, r212 = SSR/SSTO ... 2-9 ... SSE = SSTO − SSR = ... 1 − r212 ... r12 = ... SSR ... SSTO ...

Total population: R2 = 0.884067 Number of hospital beds: R2 = 0.903383 Total personal income: R2 = 0.898914 2.63. Region 1: 480.0± 1.66008(110.1), 297.2252 ≤ β1 ≤ 662.7748 Region 2: 299.3± 1.65936(154.2), 43.42669 ≤ β1 ≤ 555.1733 Region 3: 272.22± 1.66508(70.34), 155.8017 ≤ β1 ≤ 388.6383 Region 4: 508.0± 1.66543(359.0), −89.88937

≤ β1 ≤ 1105.889 2.64. Infection rate: R2 = .2846 Facilities: R2 = .1264 X-ray: R2 = .1463 2.65. Region 1: 1.3478± 2.056(.316), .6981 ≤ β1 ≤ 1.9975 Region 2: .4832± 2.042(.137), .2034 ≤ β1 ≤ .7630 Region 3: .5251± 2.031(.111), .2997 ≤ β1 ≤ .7505 Region 4: .0173± 2.145(.306), −.6391 ≤ β1 ≤ .6737 2.66. a. E{Yh} = 36 when Xh = 4, E{Yh} = 52 when Xh = 8, E{Yh} = 68 when Xh = 12, E{Yh} = 84 when Xh = 16, E{Yh} = 100 when Xh = 20 c. E{b1} = 4, σ{b1} = √25 160= .3953 d. Expected proportion is .95 2-11 Chapter 3 DIAGNOSTICS AND REMEDIALMEASURES 3.3.b.and c. i: 1 2 3 . .
. 118 119 120 Yi: 3.29942 2.65763 3.20121 . .
. 3.20121 2.73528 3.20121ei: 0.967581 1.22737 0.57679 . . . 0.71279 -0.87528 -0.25321 d. Ascending order: 1 2 3 . . . 119 120Ordered residual: -2.74004 -1.83169 -1.24373 . .
. 0.99441 1.22737Expected value: [illegible] H0: Normal, Ha: not normal. r = 0.97373. If r ≥ .987 conclude H0, otherwise Ha.Conclude Ha. e. n1 = 65, d1 = 0.43796, n2 = 55, d2 = 0.50652, s = 0.417275, t∗BF = (0.43796 −0.50652)/0.417275 √(1/65) + (1/55) = −0.89674, t(.995; 118) = 2.61814. If |t∗BF | ≤ 2.61814 conclude error variance constant, otherwise error variance not constant.Conclude error variance constant. 3.4.c and d. i: 1 2 . . . 44 45 Yi: 29.49034 59.56084 . . . 59.56084 74.59608ei: -9.49034 0.43916 . . . 1.43916 2.40392 e.
Ascending order: 1 2 . .
44 45Ordered residual: -22.77232 -19.70183 . . . 14.40392 15.40392Expected value: -19.63272 -16.04643 . . . 16.04643 19.63272 H0: Normal, Ha: not normal. r = 0.9891. If r ≥ .9785 conclude H0, otherwiseHa. Conclude H0. g. SSR∗ = 15, 155, SSE = 3416.38, X2BP = (15, 155/2) ÷ (3416.38/45)2 = 1.314676, χ2(.95; 1) = 3.84. If X2BP ≤ 3.84 conclude error variance constant, otherwise error variance not constant. Conclude error variance constant.
3.5. c. i: 1 2 3 4 5 6 7 8 9 10ei: 1.8 -1.2 -1.2 1.8 -.2 -1.2 -2.2 .8 .8 .8 Ascending Order: 1 2 3 4 5 6 7 8 9 10Ordered residual: -2.2 -1.2 -1.2 -1.2 -.2 .8 .8 .8 1.8 1.8Expected value: -2.3 -1.5 -1.0 -.6 -.2 .2 .6 1.0 1.5 2.3 H0: Normal, Ha: not normal. r = .961. If r ≥ .879 conclude H0, otherwise Ha.Conclude H0.
g. SSR∗ = 6.4, SSE = 17.6, X2BP = (6.4/2) ÷ (17.6/10)2 = 1.03, χ2(.90; 1) = 2.71. If X2BP ≤ 2.71 conclude error variance constant, otherwise error variance not constant. Conclude error variance constant. Yes. 3.6.a and b. i: 1 2 3 4 5 6ei: -2.150 3.850 -5.150 -1.150 .575 2.575 Yi: 201.150 201.150 201.150 201.150 217.425 217.425 i: 7 8 9 10 11 12ei: -2.425 5.575 3.300 .300 1.300 -3.700 Yi: 217.425 217.425 233.700 233.700 233.700 233.700 i: 13 14 15 16ei: .025 -1.975 3.025 -3.975 Yi: 249.975 249.975 249.975 249.975 c and d. Ascending order: 1 2 3 4 5 6Ordered residual: -5.150 -3.975 -3.700 -2.425 -2.150 -1.975 Expected value: [illegible] e∗i : [illegible] Ascending order: 7 8 9 10 11 12Ordered residual: -1.150 .025 .300 .575 1.300 2.575Expected value: [illegible] e∗i : [illegible] Ascending order: 13 14 15 16Ordered residual: 3.025 3.300 3.850 5.575Expected value: [illegible] e∗i : [illegible] H0: Normal, Ha: not normal. r = .992.
If r ≥ .941 conclude H0, otherwise Ha.Conclude H0. t(.25; 14) = −.692, t(.50; 14) = 0, t(.75; 14) = .692 Actual: 4/16 7/16 11/16 e. n1 = 8, d1 = 2.931, n2 = 8, d2 = 2.194, s = 1.724, t∗BF = (2.931 − 2.194)/1.724√(1/8) + (1/8) = .86, t(.975; 14) = 2.145. If |t∗BF | ≤ 2.145 conclude error variance constant, otherwise error variance not constant.Conclude error variance constant. 3-2 3.7.b and c. i: 1 2 . . . 59 60ei: 0.82324 -1.55675 . .
. -0.66689 0.89309 Yi: 105.17676 107.55675 . . .
70.66689 65.90691 d. Ascending order: 1 2 . . . 59 60Ordered residual: -16.13683 -13.80686 . . . 13.95312 23.47309Expected value: -18.90095 -15.75218 . .
. 15.75218 18.90095 H0: Normal, Ha: not normal. r = 0.9897. If r ≥ 0.984 conclude H0, otherwise Ha. Conclude H0. e. SSR∗ = 31, 833.4, SSE = 3, 874.45, X2BP = (31, 833.4/2) ÷ (3, 874.45/60)2 = 3.817116, χ2(.99; 1) = 6.63. If X2 BP ≤ 6.63 conclude error variance constant, otherwise error variance not constant. Con-clude error variance constant. Yes.
3.8.b and c. i: 1 2 . .
. 83 84ei: 591.964 1648.566 . . . 621.141 28.114 Yi: 7895.036 6530.434 . . . 6359.859 7553.886 d.
Ascending order: 1 2 . . . 83 84Ordered residual: -5278.310 -3285.062 . . . 4623.566 6803.265Expected value: -5740.725 -4874.426 . . . 4874.426 5740.725 H0: Normal, Ha: not normal. r = 0.98876. If r ≥ 0.9854 conclude H0, otherwise Ha. Conclude H0. e. n1 = 8, d1 = 1751.872, n2 = 76, d2 = 1927.083, s = 1327.772, t∗BF = (1751.872 − 1927.083)/1327.772 √(1/8) + (1/76) = −0.35502, t(.975; 82) = 1.98932. If |t∗BF | ≤ 1.98932 conclude error variance constant, otherwise error variance not constant. Conclude error variance constant. 3.10. b. 4, 3.11. b. SSR∗ = 330.042, SSE = 59.960, X2BP = (330.042/2) ÷ (59.960/9)2 = 3.72, χ2(.95; 1) = 3.84. If X2BP ≤ 3.84 conclude error variance constant, otherwise error variance not constant. Conclude error variance constant. 3.13. a. H0: E{Y} = β0 + β1X, Ha: E{Y} 6= β0 + β1X b. SSPE = 2797.66, SSLF = 618.719, F∗ = (618.719/8) ÷ (2797.66/35) = 0.967557, F(.95; 8, 35) = 2.21668. If F∗ ≤ 2.21668 conclude H0, otherwise Ha.Conclude H0. 3.14. a. H0: E{Y} = β0 + β1X, Ha: E{Y} 6= β0 + β1X. SSPE = 128.750, SSLF = 17.675, F∗ = (17.675/2) ÷ (128.750/12) = .824, F(.99; 2, 12) = 6.93. If F∗ ≤ 6.93 conclude H0, otherwise Ha. Conclude H0. 3-3 3.15. a. Y = 2.57533 − 0.32400X [illegible] E{Y} = β0 + β1X, Ha: E{Y} 6= β0 + β1X. SSPE = .1575, SSLF = 2.7675, F∗ = (2.7675/3) ÷ (.1575/10) = 58.5714, F(.975; 3, 10) = 4.83.
If F∗ ≤ 4.83 conclude H0, otherwise Ha. Conclude Ha. 3.16. b. λ: −.2 −.1 0 .1 .2SSE: .1235 .0651 .0390 .0440 .0813 c. Y′ = .65488− .19540X e. [illegible]
[illegible] f. Y = antilog10(.65488−.19540X) = 4.51731(.63768)X 3.17. b. λ: .3 .4 .5 .6 .7SSE: 1099.7 967.9 916.4 942.4 1044.2 c. Y′ = 10.26093 + 1.07629X e.
[illegible] f. Y = (10.26093 + 1.07629X)2 3.18. b. Y′ = 1.25470− 3.62352X′ [illegible]

[illegible]

Chapter 4 SIMULTANEOUS INFERENCESAND OTHER TOPICS INREGRESSION ANALYSIS 4.1. No, no 4.2. 90 percent 4.3. a. Opposite directions, negative tilt b. B = t(.9875; 43) = 2.32262, b0 = −0.580157, s{b0} = 2.80394, b1 = 15.0352, s{b1} = 0.483087 −0.580157± 2.32262(2.80394) −7.093 ≤ β0 ≤ 5.932 15.0352± 2.32262(0.483087) 13.913 ≤ β1 ≤ 16.157 c. Yes 4.4. a. Opposite directions, negative tilt b.
B = t(.9975; 8) = 3.833, b0 = 10.2000, s{b0} = .6633, b1 = 4.0000, s{b1} = .4690 [illegible] 4.5. a. B = t(.975; 14) = 2.145, b0 = 168.6000, s{b0} = 2.6570, b1 = 2.0344, s{b1} = .0904 [illegible] b. Negatively, no 4.6. a. B = t(.9975; 14) = 2.91839, b0 = 156.347, s{b0} = 5.51226, b1 = −1.190, s{b1} = 0.0901973 [illegible] b. Opposite directions 4-1 c. No 4.7. a. F(.90; 2, 43) = 2.43041, W = 2.204727 [illegible]

[illegible]

variance constant, otherwise error variance not constant. Conclude error variance constant. f. H0: E{Y} = β0 + β1X1 + β2X2, Ha: E{Y} 6= β0 + β1X1 + β2X2. MSLF = 7.46, MSPE = 7.125, F∗ = 7.46/7.125 = 1.047, F(.99; 5, 8) = 6.63.
If F∗ ≤ 6.63conclude H0, otherwise Ha. Conclude H0. 6.6. a. H0: β1 = β2 = 0, Ha: not all βk = 0 (k = 1, 2). MSR = 936.350,MSE = 7.254,F∗ = 936.350/7.254 = 129.083, F(.99; 2, 13) = 6.70. If F∗ ≤ 6.70 conclude H0,otherwise Ha. Conclude Ha. b. P -value = 0+ c. s{b1} = .301, s{b2} = .673, B = t(.9975; 13) = 3.372 4.425± 3.372(.301) 3.410 ≤ β1 ≤ 5.440 4.375± 3.372(.673) 2.106 ≤ β2 ≤ 6.644 6.7. a. SSR = 1, 872.7, SSTO = 1, 967.0, R2 = .952 b. .952, yes. 6.8. a.
Yh = 77.275, s{Yh} = 1.127, t(.995; 13) = 3.012, 77.275± 3.012(1.127), 73.880 ≤ E{Yh} ≤ 80.670 b. s{pred} = 2.919, 77.275± 3.012(2.919), 68.483 ≤ Yh(new) ≤ 86.067 6.9. c. YX1 X2 X3 1.0000 .2077 .0600 .81061.0000 .0849 .0457 1.0000 .11341.0000 6.10. a. Y = 4149.89 + 0.000787X1 − 13.166X2 + 623.554X3 b&c. i: 1 2 . . . 51 52ei: −32.0635 169.2051 . . . −184.8776 64.5168 Expected Val.: −24.1737 151.0325 . .
. −212.1315 75.5358 e. n1 = 26, d1 = 145.0, n2 = 26, d2 = 77.4, s = 81.7, t∗BF = (145.0 − 77.4)/[81.7√ (1/26) + (1/26)] = 2.99, t(.995; 50) = 2.67779. If |t∗BF | ≤ 2.67779 conclude error variance constant, otherwise error variance notconstant. Conclude error variance not constant. 6.11. a. H0: β1 = β2 = β3 = 0, Ha: not all βk = 0 (k = 1, 2,3). MSR = 725, 535,MSE = 20, 531.9, F∗ = 725, 535/20, 531.9 = 35.337, F(.95; 3, 48) = 2.79806. IfF∗ ≤ 2.79806 conclude H0 otherwise Ha. Conclude Ha. P -value = 0+. b. s{b1} = .000365, s{b3} = 62.6409, B = t(.9875; 48) = 2.3139 0.000787± 2.3139(.000365) − .000058 ≤ β1 ≤ 0.00163 623.554± 2.3139(62.6409) 478.6092 ≤ β3 ≤ 768.4988 6-2 c. SSR = 2, 176, 606, SSTO = 3, 162, 136, R2 = .6883 6.12. a.
F(.95; 4, 48) = 2.56524, W = 3.2033; B = t(.995; 48) = 2.6822 Xh1 Xh2 Xh3 302, 000 7.2 0:245, 000 7.4 0:280, 000 6.9 0:350, 000 7.0 0:295, 000 6.7 1: 4292.79± 2.6822(21.3567)4245.29± 2.6822(29.7021)4279.42± 2.6822(24.4444)4333.20± 2.6822(28.9293)4917.42± 2.6822(62.4998) 4235.507 ≤ E{Yh} ≤ 4350.0734165.623 ≤ E{Yh} ≤ 4324.9574213.855 ≤ E{Yh} ≤ 4344.9854255.606 ≤ E{Yh} ≤ 4410.7944749.783 ≤ E{Yh} ≤ 5085.057 b.Yes, no 6.13. F(.95; 4, 48) = 2.5652, S = 3.2033; B = t(.99375; 48) = 2.5953Xh1 Xh2 Xh3 230, 000 7.5 0:250, 000 7.3 0:280, 000 7.1 0:340, 000 6.9 0: 4232.17± 2.5953(147.288)4250.55± 2.5953(146.058)4276.79± 2.5953(145.134)4326.65± 2.5953(145.930) 3849.913 ≤ Yh(new) ≤ 4614.4273871.486 ≤ Yh(new) ≤ 4629.6143900.124 ≤ Yh(new) ≤ 4653.4563947.918 ≤ Yh(new) ≤ 4705.382 6.14. a. Yh = 4278.37, s{predmean} = 85.82262, t(.975; 48) = 2.01063, 4278.37± 2.01063(85.82262), 4105.812 ≤ Yh(new) ≤ 4450.928 b. 12317.44 ≤ Total labor hours≤ 13352.78 6.15. b. YX1 X2 X3 1.000 −.7868 −.6029 −.64461.000 .5680 .5697 1.000 .67051.000 c. Y = 158.491− 1.1416X1 − 0.4420X2 − 13.4702X3 d&e. i: 1 2 . . . 45 46ei: .1129 −9.0797 . . . −5.5380 10.0524 Expected Val.: −0.8186 −8.1772 . . .
−5.4314 8.1772 f. No g. SSR∗ = 21, 355.5, SSE = 4, 248.8, X2BP = (21, 355.5/2) ÷ (4, 248.8 /46)2 = 1.2516, χ2(.99; 3) = 11.3449. If X2BP ≤ 11.3449 conclude error variance constant, otherwise error variance not constant. Conclude error variance constant. 6.16. a. H0: β1 = β2 = β3 = 0, Ha: not all βk = 0 (k = 1, 2, 3).
MSR = 3, 040.2, MSE = 101.2, F∗ = 3, 040.2/101.2 = 30.05, F(.90; 3, 42) = 2.2191. If F∗ ≤ 2.2191 conclude H0, otherwise Ha. Conclude Ha. P -value =0.4878 b. s{b1} = .2148, s{b2} = .4920, s{b3} = 7.0997, B = t(.9833; 42) = 2.1995 −1.1416± 2.1995(.2148) − 1.6141 ≤ β1 ≤ −0.6691 −.4420± 2.1995(.4920) − 1.5242 ≤ β2 ≤ 0.6402 −13.4702± 2.1995(7.0997) − 29.0860 ≤ β3 ≤ 2.1456 6-3 c. SSR = 9, 120.46, SSTO = 13, 369.3, R = .8260 6.17.
a. Yh = 69.0103, s{Yh} = 2.6646, t(.95; 42) = 1.6820, 69.0103 ± 1.6820(2.6646),64.5284 ≤ E{Yh} ≤ 73.4922 b. s{pred} = 10.405, 69.0103± 1.6820(10.405), 51.5091 ≤ Yh(new) ≤ 86.5115 6.18. b. YX1 X2 X3 X4 1.0000 −.2503 .4138 .0665 .53531.0000 .3888 −.2527 .2886 1.0000 −.3798 .44071.0000 .0806 1.0000 c. Y = 12.2006− .1420X1 + .2820X2 + 0.6193X3 + 0.0000079X4 d&e.i: 1 2 . . . 80 81 ei: −1.0357 −1.5138 .
. . −2.0302 −.9068Expected Val.: −1.1524 −1.5857 . . .
−1.9321 −1.0407 f. No g. n1 = 40, d1 = 0.8696, n2 = 41, d2 = 0.7793, s = 0.7357, t∗BF = (0.8696 −0.7793)/0.7357 √(1/40) + (1/41) = 0.5523, t(.975; 79) = 1.9905.
If |t∗BF | ≤ 1.9905 conclude error variance constant, otherwise error variance not constant. Concludeerror variance constant. 6.19. a. H0: β1 = β2 = β3 = β4 = 0, Ha: not all βk = 0 (k = 1, 2, 3, 4). MSR = 34.5817MSE = 1.2925, F∗ = 34.5817/1.2925 = 26.7557, F(.95; 4, 76) = 2.4920. IfF∗ ≤ 2.4920 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ b. s{b1} = .02134, s{b2} = .06317, s{b3} = 1.08681, s{b4} = .00000138, B =t(.99375; 76) = 2.5585 −.1420± 2.5585(.02134) −.1966 ≤ β1 ≤ −.0874 .2820± 2.5585(.06317) .1204 ≤ β2 ≤ .4436 .6193± 2.5585(1.08681) −2.1613 ≤ β3 ≤ 3.3999 .0000079± 2.5585(.00000138) .0000044 ≤ β1 ≤ .0000114 c. SSR = 138.327, SSTO = 236.5576, R2 = .5847 6.20. F(.95; 5, 76) = 2.3349, W = 3.4168; B = t(.99375; 76) = 2.5585Xh1 Xh2 Xh3 Xh4 5 8.25 0 250, 000:6 8.50 .23 270, 000:14 11.50 .11 300, 000:12 10.25 0 310, 000: 15.7981± 2.5585(.2781) 15.087 ≤ E{Yh} ≤ 16.51016.0275± 2.5585(.2359) 15.424 ≤ E{Yh} ≤ 16.63115.9007± 2.5585(.2222) 15.332 ≤ E{Yh} ≤ 16.46915.8434± 2.5585(.2591) 15.180 ≤ E{Yh} ≤ 16.506 6.21. t(.975; 76) = 1.9917 Xh1 Xh2 Xh3 Xh4 4 10.0 0.10 80, 000: 15.1485± 1.9917(1.1528) 12.852 ≤ Yh(new) ≤ 17.4456 11.5 0 120, 000: 15.5425± 1.9917(1.1535) 13.245 ≤ Yh(new) ≤ 17.84012 12.5 .32 340, 000: 16.9138± 1.9917(1.1946) 14.535 ≤ Yh(new) ≤ 19.293 6-4 85 percent 6.22. a. Yes b. No, yes, Y ′i = loge Yi = β0 + β1Xi1 + β2X 2i2 + ε′i, where ε′i = loge εi c.
Yes d. No, no e. No, yes, Y ′i = loge(Y −1i − 1) = β0 + β1Xi1 + εi 6.23. a. Q =∑ (Yi − β1Xi1 − β2Xi2)2 ∂Q ∂β1 = −2∑ (Yi − β1Xi1 − β2Xi2)Xi1 ∂Q ∂β2 = −2∑ (Yi − β1Xi1 − β2Xi2)Xi2 Setting the derivatives equal to zero, simplifying, and substituting the least squaresestimators b1 and b2 yields:∑ YiXi1 − b1∑ X2i1 − b2 ∑Xi1Xi2 = 0 ∑YiXi2 − b1 ∑Xi1Xi2 − b2 ∑X2 i2 = 0 and: b1 = ∑YiXi2 ∑Xi1Xi2 −∑ YiXi1∑ X2i2 (∑ Xi1Xi2)2 −∑ X2i1 ∑X2 i2 b2 = ∑YiXi1 ∑Xi1Xi2 −∑ YiXi2∑ X2i1 (∑ Xi1Xi2)2 −∑ X2i1 ∑X2 i2 b. L =n∏ i=1 1√2πσ2 exp[− 1 2σ2(Yi − β1Xi1 − β2Xi2) 2] It is more convenient to work with loge L: loge L = −n 2loge(2πσ2)− 1 2σ2 ∑(Yi − β1Xi1 − β2Xi2) 2 ∂ loge L ∂β1 =1 σ2 ∑(Yi − β1Xi1 − β2Xi2)Xi1 ∂ loge L ∂β2 =1 σ2 ∑(Yi − β1Xi1 − β2Xi2)Xi2 Setting the derivatives equal to zero, simplifying, and substituting the maximumlikelihood estimators b1 and b2 yields the same normal equations as in part (a),and hence the same estimators. 6.24. a. Q =∑ (Yi − β0 − β1Xi1 − β2X2i1 − β3Xi2) 2 ∂Q ∂β0 = −2∑ (Yi − β0 − β1Xi1 − β2X2i1 − β3Xi2) ∂Q ∂β1 = −2∑ (Yi − β0 − β1Xi1 − β2X2i1 − β3Xi2)Xi1 ∂Q ∂β2 = −2∑ (Yi − β0 − β1Xi1 − β2X2i1 − β3Xi2)X 2i1 6-5 ∂Q ∂β3 = −2∑ (Yi − β0 − β1Xi1 − β2X2i1 − β3Xi2)Xi2 Setting the derivatives equal to zero, simplifying, and substituting the least squaresestimators b0, b1, b2, and b3 yields the normal equations:∑ Yi − nb0 − b1∑ Xi1 − b2∑ X2i1 − b3 ∑Xi2 = 0 ∑YiXi1 − b0 ∑Xi1 − b1 ∑X2 i1 − b2∑ X3i1 − b3 ∑Xi1Xi2 = 0 ∑YiX 2i1 − b0 ∑X2 i1 − b1∑ X3i1 − b2 ∑X4 i1 − b3∑ X2i1Xi2 = 0 ∑YiXi2 − b0 ∑Xi2 − b1 ∑Xi1Xi2 − b2 ∑X2 i1Xi2 − b3∑ X2i2 = 0 b. L =n∏ i=1 1√2πσ2 exp[− 1 2σ2(Yi − β0 − β1Xi1 − β2X 2i1 − β3Xi2) 2] or loge L = −n 2loge(2πσ2)− 1 2σ2 ∑(Yi − β0 − β1Xi1 − β2X 2i1 − β3Xi2) 2 6.25. Fit Y ′i = β0 + β1Xi1 + β3Xi3 + εi, where Y ′ i = Yi − 4Xi2 6.26. For regression model (6.1), R2 = 1− SSE(X1, X2) SSTO When regressing Yi on Yi, SSTO remains unchanged and the fitted regression equation: Y ∗i = b∗0 + b∗1Yi has coefficients b∗0 = 0, b∗1 = 1 because: b∗1 = ∑(Yi − Y)(Yi − Y) ∑(Yi − Y)2 = ∑(Yi − Y)[(Yi − Yi) + (Yi − Y)] ∑(Yi − Y)2 = ∑(Yi − Y)[ei + (Yi − Y)] ∑(Yi − Y)2 = 1 since∑ eiYi = 0 and∑ eiY = 0 by (1.20) and (1.17). b∗0 = Y − b∗1Y = 0 Hence Y ∗i = Yi and SSE(Y) = ∑(Yi − Y ∗ i)2 =∑ (Yi − Yi)2 = SSE(X1, X2), and: r2 = 1− SSE(Y) SSTO= 1− SSE(X1, X2) SSTO= R2 6.27. a. 33.932102.78476−.26442 6-6 b. −2.6996−1.2300−1.6374−1.3299−.09006.9868 c. .2314 .2517 .2118 .1489 −.0548 .2110 .2517 .3124 .0944 .2663 −.1479 .2231 .2118 .0944 .7044 −.3192 .1045 .2041 .1489 .2663 −.3192 .6143 .1414 .1483−.0548 −.1479 .1045 .1414 .9404 .0163 .2110 .2231 .2041 .1483 .0163 .1971 d. 3,009.926 e. 715.4711 −34.1589 −13.5949−34.1589 1.6617 .6441−13.5949 .6441 .2625 f. 53.8471 g. 5.4247 6.28. b.
Model I:YX1 X2 X3 1.0000 0.9402 0.0781 0.94811.0000 0.1731 0.9867 1.0000 0.12711.0000 Model II:YX1 X2 X3 1.0000 0.4064 −0.0031 0.94811.0000 0.0292 0.3162 1.0000 −0.02271.0000 c. Model I: Y = −13.3162 + 0.000836618X1 − 0.065523X2 + 0.094132X3 Model II: Y = −170.574 + 0.0961589X1 + 6.33984X2 + 0.126566X3 d. Model I: 0.902643 Model II: 0.911749 6.29. a. Region 1: Y = −26, 140 + 16.34X1 + 0.3834X2 + 291.1X3 Region 2: Y = 63, 104.1209 + 2.5883X1 + 3.6022X2 − 854.5493X3 Region 3: Y = 56, 929.3851 + 0.3065X1 + 4.8955X2 − 800.3958X3 Region 4: Y = 37, 720− 0.9915X1 + 3.627X2 − 489.0X3 c.MSE R2 Region 1: 8.0728× 108 0.831Region 2: 1.4017× 108 0.9392Region 3: 1.9707× 108 0.8692Region 4: 2.1042× 108 0.9713 6-7 6.30.
b. Model I: YX1 X2 X3 1.000 .189 .533 .3561.000 .001 −.040 1.000 .4131.000 Model II: YX1 X2 X3 1.000 .409 .533 .3561.000 .360 .795 1.000 .4131.000 c.
Model I: Y = 1.38646 + .08371X1 + .65845X2 + .02174X3 Model II: Y = 6.46738 + .00302X1 + .64771X2 − .00929X3 d. Model I: .3448 Model II: .3407 6.31. a.
Region 1: Y = −3.34958 + .11695X1 + .05824X2 + .00151X3 + .00661X4 Region 2: Y = 2.29154 + .00474X1 + .05803X2 + .00117X3 + .01502X4 Region 3: Y = −.14386 + .03085X1 + .10228X2 + .00411X3 + .00804X4 Region 4: Y = 1.56655 + .03524X1 + .04033X2 − .00066X3 + .01279X4 MSE R2 Region 1: 1.022 .4613Region 2: 1.212 .4115Region 3: .937 .6088Region 4: .954 .0896 6-8 Chapter 7 MULTIPLE REGRESSION – II 7.1. (1) 1 (2) 1 (3) 2 (4) 3 7.3. a. SSR(X1) = 1, 566.45, SSR(X2|X1) = 306.25, SSE(X1, X2) = 94.30, df : 1, 1, 13. b. H0: β2 = 0, Ha: β2 6= 0. SSR(X2|X1) = 306.25, SSE(X1, X2) = 94.30, F∗ =(306.25/1)÷ (94.30/13) = 42.219, F(.99; 1, 13) = 9.07. If F∗ ≤ 9.07 conclude H0,otherwise Ha. Conclude Ha. P -value = 0+. 7.4. a. SSR(X1) = 136, 366, SSR(X3|X1) = 2, 033, 566, SSR(X2|X1, X3) = 6, 674,SSE(X1, X2, X3) = 985, 530, df : 1, 1, 1,48. b. H0: β2 = 0, Ha: β2 6= 0. SSR(X2|X1, X3) = 6, 674, SSE(X1, X2, X3) = 985, 530,F∗ = (6, 674/1) ÷ (985, 530/48) = 0.32491, F(.95; 1, 17) = 4.04265. If F∗ ≤4.04265 conclude H0, otherwise Ha. Conclude H0. P -value = 0.5713. c. Yes, SSR(X1)+SSR(X2|X1) = 136, 366+5, 726 = 142, 092, SSR(X2)+SSR(X1|X2) =11, 394.9 + 130, 697.1 = 142, 092. Yes. 7.5. a. SSR(X2) = 4, 860.26, SSR(X1|X2) = 3, 896.04, SSR(X3|X2, X1) = 364.16,SSE(X1, X2, X3) = 4, 248.84, df : 1, 1, 1, 42 b. H0: β3 = 0, Ha: β3 6= 0. SSR(X3|X1, X2) = 364.16, SSE(X1, X2, X3) =4, 248.84,F∗ = (364.16/1)÷(4, 248.84/42) = 3.5997, F(.975; 1, 42) = 5.4039. If F∗ ≤ 5.4039conclude H0, otherwise Ha .
Conclude H0.
P -value = 0.065. 7.6. H0: β2 = β3 = 0, Ha: not both β2 and β3 = 0. SSR(X2, X3|X1) = 845.07,SSE(X1, X2, X3) = 4, 248.84, F∗ = (845.07/2)÷(4, 248.84/42) = 4.1768, F(.975; 2, 42) =4.0327.
If F∗ ≤ 4.0327 conclude H0, otherwise Ha. Conclude Ha. P -value = 0.022. 7.7. a. SSR(X4) = 40.5033, SSR(X1|X4) = 42.2746, SSR(X2|X1, X4) = 27.8575,SSR(X3|X1, X2, X4) = 0.4195, SSE(X1, X2, X3, X4) = 98.2306, df : 1, 1, 1, 1, 76. b. H0: β3 = 0, Ha: β3 6= 0. F∗ = (0.42/1) ÷ (98.2306/76) = 0.3249, F(.99; 1, 76) =6.9806. If F∗ ≤ 6.9806 conclude H0, otherwise Ha. Conclude H0. P -value= .5704. 7-1 7.8. H0: β2 = β3 = 0, Ha: not both β2 and β3 = 0. SSR(X2, X3|X1, X4) = 28.277,SSE(X1, X2, X3, X4) = 98.2306, F∗ = (28.277/2)÷(98.2306/76) = 10.9388, F(.99; 2, 20) =4.8958. If F∗ ≤ 4.8958 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+. 7.9. H0: β1 = −1.0, β2 = 0; Ha: not both equalities hold.
Full model: Yi = β0 + β1Xi1 +β2Xi2 + β3Xi3 + εi, reduced model: Yi + Xi1 = β0 + β3Xi3 + εi.
SSE(F) = 4, 248.84,dfF = 42, SSE(R) = 4, 427.7, dfR = 44, F∗ = [(4427.7−4248.84)/2]÷(4, 248.84/42) =.8840, F(.975; 2, 42) = 4.0327. If F∗ ≤ 4.0327 conclude H0, otherwise Ha. ConcludeH0. 7.10. H0: β1 = −.1, β2 = .4; Ha: not both equalities hold. Full model: Yi = β0 + β1Xi1 +β2Xi2 +β3Xi3 +β4Xi4 +εi, reduced model: Yi + .1Xi1− .4Xi2 = β0 +β3Xi3 +β4Xi4 +εi.SSE(F) = 98.2306, dfF = 76, SSE(R) = 110.141, dfR = 78, F∗ = [(110.141 −98.2306)/2]÷ (98.2306/76) = 4.607, F(.99; 2, 76) = 4.89584. If F∗ ≤ 4.89584 concludeH0, otherwise Ha. Conclude H0. 7.11. a. R2Y 1 = .550, R2 Y 2 = .408, R212 = 0, R2 Y 1|2 = .929, R2Y 2|1 = .907, R2 = .958 7.12.
R2Y 1 = .796, R2 Y 2 = .156, R212 = 0, R2 Y 1|2 = .943, R2Y 2|1 = .765, R2 = .952 7.13. R2Y 1 = .0431, R2 Y 2 = .0036, R212 = .0072, R2 Y 1|2 = 0.0415, R2Y 2|1 = 0.0019, R2Y 2|13 = .0067 R2 = .6883 7.14. a. R2Y 1 = .6190, R2 Y 1|2 = .4579, R2Y 1|23 = .4021 b. R2Y 2 = .3635, R2 Y 2|1 = .0944, R2Y 2|13 = .0189 7.15. R2Y 4 = .2865, R2 Y 1 = .0626, R2Y 1|4 = .2505, R2 14 = .4652, R2Y 2|14 = .2202, R2 Y 3|124 = .0043, R2 = .5848 7.16. a. Y∗ = .89239X∗1 + .39458X∗ 2 c. sY = 11.45135, s1 = 2.30940, s2 = 1.03280, b1 =11.45135 2.30940(.89239) = 4.425, b2 =11.45135 1.03280(.39458) = 4.375, b0 = 81.7500− 4.425(7)− 4.375(3) = 37.650. 7.17. a. Y∗ = .17472X∗1 − .04639X∗ 2 + .80786X∗3 b. R212 = .0072, R2 13 = .0021,R223 = .0129 c. sY = 249.003, s1 = 55274.6, s2 = .87738, s3 = .32260 b1 =249.003 55274.6(.17472) = .00079, b2 =249.003 .87738(−.04639) = −13.16562, b3 = 249.003 5.32260(.80786) = 623.5572, b0 = 4363.04−.00079(302, 693) +13.16562(7.37058)−623.5572(0.115385) = 4149.002. 7.18. a. Y∗ = −.59067X∗1 − .11062X∗ 2 − .23393X∗3 b.
R212 = .32262, R2 13 = .32456, R223 = .44957 c. sY = 17.2365, s1 = 8.91809, s2 = 4.31356, s3 = .29934, b1 =17.2365 8.91809(−.59067) = −1.14162, b2 =17.2365 4.31356(−.11062) = −.44203, b3 = 17.2365 .29934(−.23393) = −13.47008, b0 = 61.5652+1.14162(38.3913) +.44203(50.4348)+13.47008(2.28696) = 158.4927 7-2 7.19. a. Y∗ = −.547853X∗1 + .423647X∗ 2 + .0484614X∗3 + .502757X∗ 4 c. sY = 1.71958, s1 = 6.63278, s2 = 2.58317, s3 = .13455,s4 = 109099, b1 =1.71958 6.63278(−.547853) = −.14203, b2 = 1.71958 2.58317(.423647) = .28202, b3 =1.71958 .13455(.0484614) = .61934, b4 = 1.71958 109099(.502757) = 7.9243 × 10−6, b0 = 15.1389 + .14203(7.8642) − .28202(9.68815) − .61934(.08099) − 7.9243 ×10−6(160633) = 12.20054. 7.21. b. The line of fitted values when .5X1 −X2 = −5. 7.24. a. Y = 50.775 + 4.425X1 c. Yes, SSR(X1) = 1, 566.45, SSR(X1|X2) = 1, 566.45 d. r12 = 0 7.25. a. Y = 4079.87 + 0.000935X2 c.
No, SSR(X1) = 136, 366, SSR(X1|X2) = 130, 697 d. r12 = .0849 7.26. a. Y = 156.672− 1.26765X1 − 0.920788X2 c. No, SSR(X1) = 8, 275.3, SSR(X1|X3) = 3, 483.89 No, SSR(X2) = 4, 860.26, SSR(X2|X3) = 708 d. r12 = .5680, r13 = .5697, r23 = .6705 7.27. a. Y = 14.3613− .11447X1 + .00001X4 c.
No, SSR(X4) = 67.7751, SSR(X4|X3) = 66.8582 No, SSR(X1) = 14.8185, SSR(X1|X3) = 13.7744 d.
r12 = .4670, r13 = .3228, r23 = .2538 7.28. a. (1) SSR(X1, X5)− SSR(X1) or SSE(X1)− SSE(X1, X5) (2) SSR(X1, X3, X4)− SSR(X1) or SSE(X1)− SSE(X1, X3, X4) (3) SSR(X1, X2, X3, X4)− SSR(X1, X2, X3) or SSE(X1, X2, X3)− SSE(X1, X2, X3, X4) b. SSR(X5|X1, X2, X3, X4), SSR(X2, X4|X1, X3, X5) 7.29. a. SSR(X1) + SSR(X2, X3|X1) + SSR(X4|X1, X2, X3) = SSR(X1) + [SSR(X1, X2, X3)− SSR(X1)] +[SSR(X1, X2, X3, X4)− SSR(X1, X2, X3)] = SSR(X1, X2, X3, X4) b. SSR(X2, X3) + SSR(X1|X2, X3) + SSR(X4|X1, X2, X3) = SSR(X2, X3) + [SSR(X1, X2, X3)− SSR(X2, X3)] +[SSR(X1, X2, X3, X4)− SSR(X1, X2, X3)] = SSR(X1, X2, X3, X4) 7-3 7.30. a. Y = 68.625 + 4.375X2 i: 1 2 3 4 5 6ei: -13.3750 -13.1250 -16.3750 -10.1250 -5.3750 -6.1250 i: 7 8 9 10 11 12ei: -6.3750 -3.1250 5.6250 2.8750 8.6250 6.8750 i: 13 14 15 16ei: 10.6250 8.8750 16.6250 13.8750 b. X1 = 7 i: 1 2 3 4 5 6 7 8ei: -3 -3 -3 -3 -1 -1 -1 -1 i: 9 10 11 12 13 14 15 16ei: 1 1 1 1 3 3 3 3 c. r = .971 = rY 1|2 7.31. (1) Yi = β0 + β1Xi1 + β2Xi2 + β4 √Xi3 + εi (2) Yi = β0 + β1Xi1 + β2Xi2 + εi (3) Y ′i = Yi − 5(Xi1 + Xi2) = β0 + β3Xi1Xi2 + β4 √Xi3 + εi (4) Y ′i = Yi − 7 √Xi3 = β0 + β1Xi1 + β2Xi2 + β3Xi1Xi2 + εi 7.32. (1) Yi = β0 + β2Xi2 + εi (2) Yi = β1Xi1 + β2Xi2 + β3X2i1 + εi (3) Y ′i = Yi − 5X2 i1 = β0 + β1Xi1 + β2Xi2 + εi (4) Y ′i = Yi − 10 = β1Xi1 + β2Xi2 + β3X 2i1 + εi (5) Yi = β0 + βc(Xi1 + Xi2) + β3X2i1 + εi, where βc = β1 = β2 7.33. Let: yi = Yi − Y xi1 = Xi1 − X1 xi2 = Xi2 − X2 Then: SSR(X1) =(∑ xi1yi)2 ∑x2 i1 =∑ y2i r 2Y 1 by (1.10a), (2.51) and (2.84) SSE(X1) =∑ y2i − (∑ xi1yi)2 ∑x2 i1 =∑ y2i (1− r2 Y 1) SSR(X1, X2) = b1∑ xi1yi + b2∑ xi2yi by (2.43) and∑ yi = 0 Further: b1 = ∑xi1yi∑x2 i1 −[∑ y2i∑ x2i1]1/2 rY 2r12 1− r212 by (7.56) 7-4 and similarly: b2 = ∑xi2yi∑x2 i2 −[∑ y2i∑ x2i2]1/2 rY 1r12 1− r212 Substituting these expressions for b1 and b2 into SSR(X1, X2), we obtain after somesimplification: SSR(X1, X2) =1 1− r212 [∑y2 i r2Y 1 + ∑y2 i r2Y 2 − 2 ∑y2 i rY 1rY 2r12] Now by (7.36) and (7.2b), we have: r2Y 2|1 = SSR(X1, X2)− SSR(X1) SSE(X1) Substituting the earlier expressions into the above, we obtain after some simplifying: r2Y 2|1 = 1∑y2 i (1− r2Y 1)(1− r2 12)[∑ y2i r2Y 1 + ∑y2 i r2Y 2 − 2 ∑y2 i rY 1rY 2r12 − (1− r212) ∑y2 i r2Y 1] After some further simplifying, we obtain: r2Y 2|1 = (rY 2 − r12rY 1)2 (1− r2Y 1)(1− r2 12) 7.34.
a. (1) [1 00 1](2) [.7420.6385] (3) [.7420.6385](4) [.0083 0 0 .0083] b.
From (7.53), b∗1 =1.069 7.745(5.375) = .742 b∗2 =.5345 7.745(9.250) = .638 7.35. From (7.45), we have: Y ∗i = β∗1X ∗i1 + β∗2X ∗i2 + ε∗i 1√n− 1 (Yi − Y sY)= β∗1 1√n− 1 (Xi1 − X1 s1)+ β∗2 1√n− 1 (Xi2 − X2 s2)+ ε∗i Simplifying, we obtain: Yi = (Y − β∗1sY s1 X1 − β∗2sY s2 X2) + β∗1sY s1 Xi1 + β∗2sY s2 Xi2 +√ n− 1sY ε∗i 7-5 Hence: β∗1sY s1 = β1 β∗2sY s2 = β2 7.36. X∗Y= [ΣX∗ i1Y∗i ΣX∗i2Y ∗i]= Σ(Xi1 − X1)(Yi − Y) (n − 1)s1sY Σ(Xi2 − X2)(Yi − Y) (n − 1)s2sY = [rY 1 rY 2] 7.37. a. R2Y 3|12 = .02883, R2 Y 4|12 = .00384, R2Y 5|12 = .55382, R2 Y 6|12 = .00732 b. X5, yes. c. Full model: Yi = β0 + β1Xi1 + β2Xi2 + β5Xi5 + εi. H0: β5 = 0, Ha: β5 6= 0.SSR(X5|X1, X2) = 78, 070, 132, SSE(X1, X2, X5) = 62, 896, 949,F∗ = (78, 070, 132/1) ÷ (62, 896, 949/436) = 541.1801, F(.99; 1, 137) = 6.69336.If F∗ ≤ 6.69336 conclude H0, otherwise Ha. Conclude Ha. No. 7.38. a. R2Y 3|12 = .01167, R2 Y 4|12 = .13620, R2Y 5|12 = .03737, R2 Y 6|12 = .03639 b. X4, yes. c.
Full model: Yi = β0 + β1Xi1 + β2Xi2 + β4Xi4 + εi. H0: β4 = 0, Ha: β4 6= 0.SSR(X4|X1, X2) = 37.89858, SSE(X1, X2, X4) = 240.35163, F∗ = (37.89858/1)÷(240.35163/109) = 17.187, F(.95; 1, 109) = 3.93. If F∗ ≤ 3.93 conclude H0, oth-erwise Ha. Conclude Ha. No. 7-6 Chapter 8 MODELS FOR QUANTITATIVEAND QUALITATIVE PREDICTORS 8.4.
a. Y = 82.9357− 1.18396x + .0148405x2, R2 = .76317 b. H0: β1 = β11 = 0, Ha: not both β1 and β11 = 0. MSR = 5915.31, MSE = 64.409,F∗ = 5915.31/64.409 = 91.8398, F(.95; 2, 57) = 3.15884. If F∗ ≤ 3.15884 concludeH0, otherwise Ha. Conclude Ha. c. Yh = 99.2546, s{Yh} = 1.4833, t(.975; 57) = 2.00247, 99.2546 ± 2.00247(1.4833),96.2843 ≤ E{Yh} ≤ 102.2249 d. s{pred} = 8.16144, 99.2546± 2.00247(8.16144), 82.91156 ≤ Yh(new) ≤ 115.5976 e. H0: β11 = 0, Ha: β11 6= 0. s{b11} = .00836, t∗ = .0148405/.00836 = 1.7759,t(.975; 57) = 2.00247. If |t∗| ≤ 2.00247 conclude H0, otherwise Ha. ConcludeH0. Alternatively, SSR(x2|x) = 203.1, SSE(x, x2) = 3671.31, F∗ = (203.1/1) ÷(3671.31/57) = 3.15329, F(.95; 1, 57) = 4.00987. If F∗ ≤ 4.00987 conclude H0,otherwise Ha. Conclude H0.
f. Y = 207.350− 2.96432X + .0148405X2 g.
rX,X2 = .9961, rx,x2 = −.0384 8.5. a.i: 1 2 3 .
. . 58 59 60 ei: -1.3238 -4.7592 -3.8091 . . . -11.7798 -.8515 6.22023 b. H0: E{Y} = β0 + β1x + β11x2, Ha: E{Y} 6= β0 + β1x + β11x 2. MSLF = 62.8154,MSPE = 66.0595, F∗ = 62.8154/66.0595 = 0.95, F(.95; 29, 28) = 1.87519. IfF∗ ≤ 1.87519 conclude H0, otherwise Ha.Conclude H0. c. Y = 82.92730− 1.26789x + .01504x2 + .000337x3 H0: β111 = 0, Ha: β111 6= 0. s{b111} = .000933, t∗ = .000337/.000933 = .3612,t(.975; 56) = 2.00324. If |t∗| ≤ 2.00324 conclude H0, otherwise Ha. Con-clude H0. Yes. Alternatively, SSR(x3|x, x2) = 8.6, SSE(x, x2, x3) = 3662.78,F∗ = (8.6/1) ÷ (3662.78/56) = .13148, F(.95; 1, 56) = 4.01297. If F∗ ≤ 4.01297conclude H0, otherwise Ha. Conclude H0. Yes. 8.6.
a. Y = 21.0942 + 1.13736x− .118401x2, R2 = .81434 8-1 b. H0: β1 = β11 = 0, Ha: not all βk = 0 (k = 1, 11). MSR = 523.133, MSE =9.9392, F∗ = 523.133/9.9392 = 52.6333,F(.99; 2, 24) = 5.6136. If F∗ ≤ 5.6136conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ c. F(.99; 3, 24) = 5.04, W = 3.7622; B = t(.99833; 24) = 3.25756 X 10: 20.6276± 3.25756(1.8945) 14.45615 ≤ E{Yh} ≤ 26.79905 15: 11.5142± 3.25756(4.56694) − 3.36288 ≤ E{Yh} ≤ 26.39128 20: −3.5192± 3.25756(8.50084) − 31.2112 ≤ E{Yh} ≤ 24.1728 d. s{pred} = 5.54942, t(.995; 24) = 2.79694, 11.5142± 2.79694(5.54942), −4.0072 ≤Yh(new) ≤ 27.0356 e. H0: β11 = 0, Ha: β11 6= 0.
s{b11} = .02347, t∗ = −.118401/.02347 = −5.04478,t(.995; 24) = 2.79694. If |t∗| ≤ 2.79694 conclude H0, otherwise Ha. Conclude Ha.Alternatively, SSR(x2|x) = 252.989, SSE(x, x2) = 238.541, F∗ = (252.989/1) ÷(238.541/24) = 25.4536, F(.99; 1, 24) = 7.82287.
If F∗ ≤ 7.82287 conclude H0,otherwise Ha. Conclude Ha. f. Y = −26.3254 + 4.87357X − .118401X2 8.7. a.i: 1 2 . . . 26 27 ei: 3.96746 -1.42965 . . . 2.10202 -2.43692 b. H0: E{Y} = β0 + β1x + β11x2, Ha: E{Y} 6= β0 + β1x + β11x 2. MSLF = 6.65396,MSPE = 13.2244, F∗ = 6.65396/13.2244 = 0.50316, F(.99; 12, 12) = 4.15526. IfF∗ ≤ 4.15526 conclude H0, otherwise Ha.Conclude H0.
8.8. a. Y = 10.1893− .181775x1 + .0141477x21 + .314031X2 + .000008X4 b. .5927 c.
H0: β11 = 0, Ha: β11 6= 0. s{b11} = .005821, t∗ = .0141477/.005821 = 2.43046,t(.975; 76) = 1.99167. If |t∗| ≤ 1.99167 conclude H0, otherwise Ha. Conclude Ha. d.
Yh = 17.2009, s{Yh} = .37345, t(.975; 76) = 1.99167, 17.2009 ± 1.99167(.37345),16.45711 ≤ E{Yh} ≤ 17.94469 e. Y = 12.4938− .404296x1 + .0141477x21 + .314031X2 + .000008X4 8.9. a. X2 = 3: E{Y} = 37 + 7.5X1 X2 = 6: E{Y} = 49 + 12X1 8.10. a. X1 = 1: E{Y} = 21 + X2 X1 = 4: E{Y} = 42− 11X2 8.11. a. Y = 27.150 + 5.925X1 + 7.875X2 − .500X1X2 b. H0: β3 = 0, Ha: β3 6= 0. MSR(X1X2|X1, X2) = 20.0000, MSE = 6.1917,F∗ = 20.0000/6.1917 = 3.23, F(.95; 1, 12) = 4.75. If F∗ ≤ 4.75 conclude H0,otherwise Ha. Conclude H0. 8.13. E{Y} = 25.3 + .20X1 for mutual firms, 8-2 E{Y} = 13.2 + .20X1 for stock firms. 8.15. b.
Y = −0.92247 + 15.0461X1 + .75872X2 c. s{b2} = 2.77986, t(.975; 42) = 2.01808, .75872 ± 2.01808(2.77986), −4.85126 ≤β2 ≤ 6.3687 e. i: 1 2 . .
. 44 45Xi1Xi2: 2 0 . . . 0 0 ei: -9.92854 .73790 . . . 1.73790 2.69176 8.16. b.
Y = 2.19842 + .03789X1 − .09430X2 c.
H0 : β2 = 0, Ha : β2 6= 0. s{b2} = .11997, t∗ = −.09430/.11997 = −.786,t(.995; 117) = 2.6185. If |t∗| ≤ 2.6185 conclude H0, otherwise Ha. Conclude H0. d. i: 1 2 . . . 119 120Xi1Xi2: 0 14 . . . 16 0 ei: .90281 1.25037 . . . -.85042 -.31145 8.17. No 8.18. E{Y} = 25 + .30X1 for mutual firms, E{Y} = 12.5 + .35X1 for stock firms. 8.19. a. Y = 2.81311 + 14.3394X1 − 8.14120X2 + 1.77739X1X2 b. H0 : β3 = 0, Ha : β3 6= 0. s{b3} = .97459, t∗ = 1.77739/.97459 = 1.8237,t(.95; 41) = 1.68288.
If |t∗| ≤ 1.68288 conclude H0, otherwise Ha. Conclude Ha.Alternatively, SSR(X1X2|X1, X2) = 255.9, SSE(X1, X2, X1X2) = 3154.44, F∗ =(255.9/1)÷ (3154.44/ 41) = 3.32607, F(.90; 1, 41) = 2.83208. If F∗ ≤ 2.83208conclude H0, otherwise Ha. Conclude Ha. 8.20.
a. Y = 3.22632− .00276X1 − 1.64958X2 + .06224X1X2 b. H0 : β3 = 0, Ha : β3 6= 0. s{b3} = .02649, t∗ = .06224/.02649 = 2.3496,t(.975; 116) = 1.9806. If |t∗| ≤ 1.9806 conclude H0, otherwise Ha. Conclude Ha.Alternatively, SSR(X1X2|X1, X2) = 2.07126, SSE(X1, X2, X1X2) = 45.5769,F∗ = (2.07126/1) ÷ (45.5769/116) = 5.271665, F(.95; 1, 116) = 3.9229. If F∗ ≤3.9229 conclude H0, otherwise Ha. Conclude Ha. 8.21. a. Hard hat: E{Y} = (β0 + β2) + β1X1 Bump cap: E{Y} = (β0 + β3) + β1X1 None: E{Y} = β0 + β1X1 b. (1) H0 : β3 ≥ 0, Ha : β3 < 0; (2) H0 : β2 = β3, Ha : β2 6= β3 8.22. E{Y} = β0 + β1X1 Tool models M1 E{Y} = (β0 + β2) + (β1 + β5)X1 Tool models M2 8-3 E{Y} = (β0 + β3) + (β1 + β6)X1 Tool models M3 E{Y} = (β0 + β4) + (β1 + β7)X1 Tool models M4 8.24. b. Y = −126.905 + 2.7759X1 + 76.0215X2 − 1.10748X1X2, H0 : β2 = β3 = 0, Ha : not both β2 = 0 and β3 = 0. SSR(X2, X1X2| X1) = 566.15,SSE(X1, X2, X1X2) = 909.105, F∗ = (369.85/2) ÷ (909.105/60) = 12.2049,F(.95; 2, 60) = 3.15041. If F∗ ≤ 3.15041 conclude H0, otherwise Ha. ConcludeHa. c. Y = −126.9052 + 2.7759X1 for noncorner lots Y = −50.8836 + 1.6684X1 for corner lots 8.25. a. Y = 4295.72+.000903x1−(1.5767×10−9)x21+614.393X3−.000188x1X3 + (1.8076× 10−9)x21X3 b. H0 : β2 = β4 = β5 = 0, Ha : not all β2 = 0,β4 = 0 and β5 = 0.SSR(x2 1, x1X3, x21X3|x1, X3) = 1442, SSE(x1, x 21, X3, x1X3, x 21X3) = 990762, F∗ = (1442/3) ÷ (990762/46) = .02232, F(.95; 3, 46) = 2.8068. If F∗ ≤ 2.80681 con-clude H0, otherwise Ha. Conclude H0.
8.29. Set 1 XX2 X3 1 .990 .9661 − 1 xx2 x3 1 .379 .9041 − 1 Set 2 XX2 X3 1 .970 .9291 − 1 xx2 x3 1 .846 .891 − 1 8.30.dE{Y} dx= β1 + 2β11x d2E{Y}dx2 = 2β11 8.31. a. Y = b0 + b1x + b11x2 = b0 + b1(X − X) + b11(X − X)2 = b0 + b1X − b1X + b11X2 + b11X 2 − 2b11XX = (b0 − b1X + b11X2) + (b1 − 2b11X)X + b11X 2 Hence: b′0 = b0 − b1X + b11X2 b′1 = b1 − 2b11X b′11 = b11 8-4 b. A = 1 −X X2 0 1 −2X0 0 1 σ2{b} = σ20 σ01 σ02 σ01 σ21 σ12 σ02 σ12 σ22 where σ20 = σ2{b0}, σ01 = σ{b0, b1}, etc. for the regression coefficients in the transformed x variables. The variance-covariance matrix of the regression coefficients in the original Xvariables, A [σ2{b}]A′, then yields: σ2{b′0} = σ20 − 2Xσ01 + 2X2σ02 + X2σ2 1 − 2X3σ12 + X4σ22 σ2{b′1} = σ21 − 4Xσ12 + 4X2σ2 2 σ2{b′2} = σ22 σ{b′0, b′1} = σ01 − 2Xσ02 + 3X2σ12 − Xσ21 − 2X3σ2 2 σ{b′0, b′2} = σ02 − Xσ12 + X2σ22 σ{b′1, b′2} = σ12 − 2Xσ22 8.32. When Xi are equally spaced,∑ x3i = 0; hence (8.4) becomes: ∑Yi = nb0 + b11 ∑x2 i∑ xiYi = b1∑ x2i ∑x2 i Yi = b0∑ x2i + b11 ∑x4 i 8.33. a. Yi = β0+β1xi1+β2xi2+β3Xi2+β4xi1Xi2+β5x 2i1Xi2+β6Xi3+β7xi1Xi3+β8x 2i1Xi3+εi b. (1) H0 : β3 = β4 = β5 = β6 = β7 = β8 = 0 Ha : not all βk = 0 (k = 3, ..., 8) SSE(R) = SSE(x1, x21) F∗ =SSE(R)− SSE(F) 6÷ SSE(F) n− 9If F∗ ≤ F(.99; 6, n− 9) conclude H0, otherwise Ha. (2) H0 : β3 = β6 = 0, Ha : not both β3 = 0 and β6 = 0 SSE(R) = SSE(x1, x21, x1X2, x 21X2, x1X3, x 21X3) F∗ =SSE(R)− SSE(F) 2÷ SSE(F) n− 9If F∗ ≤ F(.99; 2, n− 9) conclude H0, otherwise Ha. (3) H0 : β4 = β5 = β7 = β8 = 0, Ha : not all βk = 0 (k = 4, 5, 7, 8) SSE(R) = SSE(x1, x21, X2, X3) F∗ =SSE(R)− SSE(F) 4÷ SSE(F) n− 9If F∗ ≤ F(.99; 4, n− 9) conclude H0, otherwise Ha. 8.34. a. Yi = β0 + β1Xi1 + β2Xi2 + β3Xi3 + εi b. Commercial: E{Y} = (β0 + β2) + β1X1 8-5 Mutual savings: E{Y} = (β0 + β3) + β1X1 Savings and loan: E{Y} = (β0 − β2 − β3) + β1X1 8.35. a. Let n2 = n− n1 and define: X = 1 0... ...1 01 1...
...1 1 ← n1 ← n2 Y = Y11... Yn11 Y12... Yn22 Y1 = ∑Yi1 n1 Y2 = ∑Yi2 n2 Y = ∑ ∑Yij n1 + n2 Then: X′X = [n n2 n2 n2]X′Y = [nYn2Y2] (X′X)−1 = [1n1 − 1n1− 1 n1 1n1 + 1n2] b. b = [Y1 Y2 − Y1] c. SSR = n1Y21 + n2Y 22 − nY 2 SSE =∑ ∑ Y 2ij − n1Y 21 − n2Y 22 8.36. a. Y = 999.912 + .00296x− 3.29518× 10−11x2 b. R2 = .8855 for second-order model; R2 = .6711 for first-order model. c. H0: β11 = 0, Ha: β11 6= 0. s{b11} = 1.400396 × 10−11, t∗ = −3.29518 ×10−11/1.400396 × 10−11 = −2.353, t(.975; 437) = 1.9654. If |t∗| ≤ 1.9654 con-clude H0, otherwise Ha. Conclude Ha. Alternatively, SSR(x2|x) = 2, 039, 681,SSE(x, x2) = 160, 985, 454, F∗ = (2, 039, 681/1) ÷ (160, 985, 454/437) = 5.5368,F(.95; 1, 437) = 3.8628. If F∗ ≤ 3.8628 conclude H0, otherwise Ha. Conclude Ha. 8.37. a. Y = .056288 + 0.000004585x1 − .000088x3 + 2.6982 × 10−12x21 + .00016293x2 3 +8.3337× 10−7x1x3, R2 = .2485 b. H0: β11 = β33 = β13 = 0, Ha: not all βk = 0 (k = 11, 33, 13). SSR(x21, x 23, x1x3|x1, x3) = .005477, SSE(x1, x3, x 21, x 23, x1x3) = .246385, F∗ = (.005477/3) ÷ (.246385/437) = 3.2381, F(.99; 1, 437) = 3.8267. If F∗ ≤ 3.8267conclude H0, otherwise Ha. Conclude H0. c. Y = .0584998+2.9419×10−8x1−5.5765×10−7x2+.00068244x3−3.3559×10−15x21, R2 = .1444 8.38. a. Y = 150.07921 + 7.06617x + .10116x2 b. R2 = .6569 for second-order model; R2 = .6139 for first-order model. 8-6 c. H0: β11 = 0, Ha: β11 6= 0. s{b11} = .02722, t∗ = .10116/.02722 = 3.716,t(.995; 110) = 2.621.
If |t∗| ≤ 2.621 conclude H0, otherwise Ha. Conclude Ha.Alternatively, SSR(x2|x) = 93, 533.252, SSE(x, x2) = 745, 203.642,F∗ = (93, 533.252/1) ÷ (745, 203.642/ 110) = 13.807, F(.99; 1, 110) = 6.871.
IfF∗ ≤ 6.871 conclude H0, otherwise Ha. Conclude Ha. 8.39. a. Y = −207.5 + .0005515X1 + .107X2 + 149.0X3 + 145.5X4 + 191.2X5 b. b3−b4 = 3.5, s{b3−b4} = 1.68, t(.95; 434) = 1.6484, 3.5±1.6484(1.68), 0.730688 ≤β3 − β4 ≤ 6.2693 c. H0 : β3 = β4 = β5 = 0, Ha : not all βk = 0 (k = 3, 4, 5). SSR(X3, X4, X5|X1, X2) =1, 873, 626, SSE(X1, X2, X3, X4, X5) = 139, 093, 455,F∗ = (1, 873, 626/3) ÷ (139, 093, 455/434) = 1.9487, F(.90; 3, 434) = 2.09645. IfF∗ ≤ 2.09645 conclude H0, otherwise Ha. Conclude H0. P−value=.121. 8.40. a. Y = .85738 + .28882X1 − .01805X2 + .01995X3 + .28782X4 b. s{b4} = .30668, t(.99; 108) = 2.361, .28782± 2.361(.30668), −.476 ≤ β4 ≤ 1.012 c. Y = .99413 + .26414X1 − .02283X2 + .02429X3 − 5.69520X4 + .15576X2X4 −.02406X3X4 H0 : β5 = β6 = 0, Ha : not both β5 = 0 and β6 = 0. SSR(X2X4, X3X4 |X1, X2, X3, X4) = 5.1964, SSE(X1, X2, X3, X4, X2X4, X3X4) = 122.0468, F∗ =(5.1964/2) ÷ (122.0468/106) = 2.257, F(.90; 2, 106) = 2.353. If F∗ ≤ 2.353 con-clude H0, otherwise Ha. Conclude H0. 8.41.
a. Y = 2.0478+.10369X1+.04030X2+.00660X3−.020761X4+2.14999X5+1.19033X6+.63348X7 b. H0 : β2 = 0, Ha : β2 6= 0. s{b2} = .01430, t∗ = .04030/.01430 = 2.818,t(.975; 105) = 1.983.
If |t∗| ≤ 1.983 conclude H0, otherwise Ha. Conclude Ha.Alternatively, SSR(X2|X1, X3, X4, X5, X6, X7) = 15.52782,SSE(X1, X2, X3, X4, X5, X6, X7) = 205.3634, F∗ = (15.52782/1)÷(205.3634/105) =7.9392, F(.95; 1, 105) = 3.932. If F∗ ≤ 3.932 conclude H0, otherwise Ha. Con-clude Ha. c. s{b5} = .46152, s{b6} = .43706, s{b7} = .42755, B = t(.99167; 105) = 2.433 2.14999± 2.443(.46152) 1.0225 ≤ β5 ≤ 3.2775 1.19033± 2.443(.43706) .1226 ≤ β6 ≤ 2.2581 .63348± 2.443(.42755) − .4110 ≤ β7 ≤ 1.6780 8.42.
a. Y = 3.0211−.247X1−.000097X2+.4093X3+.124X4−.01324X5{1999} −.1088X5{2001}−.08306X5{2002} b. Y = 2.38−0.453x1−0.000144x2 +0.00016x1x2 +0.92x21 +0.000001x2 2 +0.394X3 +0.115X4 + 0.012X5{1999} − 0.101X5{2001} − 0.0581X5{2002}H0 : β3 = β4 = β5 = 0, Ha : not all βk = 0 (k = 3, 4, 5). SSE(R) = .65424, dfR =28, SSE(F) = .62614, dfF = 25,MSE(F) = .02505 F∗ = .37392, F(.95; 3, 30) =2.9223. If F∗ ≤ 2.9223 conclude H0, otherwise Ha. Conclude H0. 8-7 c. H0 : β2 = β5 = β6 = β7 = 0, Ha : not all βk = 0 (k = 2, 5, 6, 7). SSE(R) = .71795, dfR = 32, SSE(F) = .65424, dfF = 28,MSE(F) = .02337, F∗ = .68154,F(.95; 4, 28) = 2.71408. If F∗ ≤ 2.71408 conclude H0, otherwise Ha. ConcludeH0. 8-8 Chapter 9 BUILDING THE REGRESSIONMODEL I: MODEL SELECTIONAND VALIDATION 9.9. Variables in Model R2p AICp Cp PRESSp None 0 262.916 88.16 13,970.10X1 .6190 220.529 8.35 5,569.56X2 .3635 244.131 42.11 9,254.49X3 .4155 240.214 35.25 8,451.43X1, X2 .6550 217.968 5.60 5,235.19X1, X3 .6761 215.061 2.81 4,902.75X2, X3 .4685 237.845 30.25 8,115.91X1, X2, X3 .6822 216.185 4.00 5,057.886 9.10. b. X1 X2 X3 X4 1 .102 .181 .3271 .519 .397 1 .7821 c. Y = −124.3820 + .2957X1 + .0483X2 + 1.3060X3 + .5198X4 9.11. a.
Subset R2a,p X1, X3, X4 .9560X1, X2, X3, X4 .9555X1, X3 .9269X1, X2, X3 .9247 9.12. Subset SBCp X3, X5, X6 −126.601X5 −124.970X3, X5, X6, X8 = 2001 −124.969 Note: Variable numbers for predictors are those in the appendix.
9-1 9.13. b. X1 X2 X3 1 .653 −.0461 −.423 1 c. Y = 87.1875− .5645X1 − .5132X2 − .0720X3 9.14. a. Subset R2a,p x1, x2, x21, x 22 .75067 x1, x2, x1x2 .75066x1, x2, x1x2, x 22 .74156 9.15. b. X1 X2 X3 1 .468 −.0891 .068 1 c.
Y = 120.0473− 39.9393X1 − .7368X2 + .7764X3 9.16. a. Subset R2a,p x1, x2, x3, x22, x1x2 .8668 x1, x2, x3, x22,x 23,x1x2 .8652 x1, x2, x3,x23, x1x2, x1x3 .8638 9.17. a. X1, X3 b. .10 c. X1, X3 d. X1, X3 9.18. a. X1, X3, X4 9.19 a. x1, x2, x3, x1x2 b. R2a,p = .8615 9.20. X3, X5, X6 in appendix. 9.21. PRESS = 760.974, SSE = 660.657 9.22. a. X1 X2 X3 X4 1 .011 .177 .3201 .344 .221 1 .8711 b. 9-2 Model-building Validationdata set data set b0: −127.596 −130.652s{b0}: 12.685 12.189 b1: .348 .347s{b1}: .054 .048 b3: 1.823 1.848s{b3}: .123 .122MSE: 27.575 21.446 R2: .933 .937 c. MSPR = 486.519/25 = 19.461 d. Y = −129.664 + .349X1 + 1.840X3, s{b0} = 8.445, s{b1} = .035, s{b3} = .084 9.23. a. PRESS = 5, 102.494, SSE = 1, 680.465 9.24. Xi = 10: [E{Y} − E{Y}]2 = (−55)2, [Y − E{Y}]2 = (−47)2 Xi = 20: [E{Y} − E{Y}]2 = (−705)2, [Y − E{Y}]2 = (−97)2 9.25. b. X3 X4 X5 X6 X7 X10 X11 X12 1 .025 −.101 .161 −.198 −.172 −.236 −.1641 .448 .334 .490 .501 .530 .453 1 .195 .168 .204 .239 .2401 .067 .086 .060 .128 1 .990 .909 .7641 .904 .729 1 .7071 Note: Variable numbers for predictor variables are those in the data set description. c.Subset Cp X3, X6, X10 3.81X3, X6, X10, X11 3.86X3, X6, X7, X10 4.27 9.26. b.X4 X6 X7 X8 X9 X11 X12 X13 X14 X15 X16 1 −.063 .016 .040 .021 −.113 −.145 .169 .181 −.190 .0781 −.599 .174 .113 .245 .486 −.025 −.222 .078 .116 1 −.023 .054 −.240 −.359 −.003 .189 −.028 −.0231 .921 .056 .264 .033 −.056 .312 .934 1 −.100 .059 .173 .034 .145 .8911 .722 −.753 −.671 .585 .087 1 −.466 −.551 .748 .2381 .513 −.649 −.052 1 −.379 −.0231 .347 1 Note: Variable numbers for predictor variables are those in the data set description. 9-3 c.Subset SBCp X6, X9, X13, X14 3407.16X6, X8, X9, X13, X14, X15 3407.41X6, X9, X13, X14, X15 3408.09 9.27. a. Model-building Validationdata set data set b0: .6104 .6189s{b0}: .0888 .1248 b3: .00388 .00399s{b3}: .00163 .00211 b6: .00117 .00152s{b6}: .000419 .000437 b10: .000293 .000157s{b10}: .0000456 .0000622MSE: .00305 .00423 R2: .519 .293 b. MSPR = .258271/56 = .00461 c. Y′ = .6272 + .00353X3 + .00143X6 + .000236X10, s{b0} = .0738, s{b3} = .00129,s{b6} = .000297, s{b10} = .0000374, where Y′ = log10 Y. 9.28.
a.
Model-building Validationdata set data set b0: 243.680 3015.63s{b0}: 1322.82 1189.63 b6: 122.507 34.3137s{b6}: 41.1906 34.2984 b9: .578662 .221509s{b9}: .075844 .057344 b13: 296.117 269.557s{b13}: 34.3417 39.0049 b14: -224.020 -128.343s{b14}: 77.1406 70.4556MSE: 4,816,124 4,484,316 R2: .463 .284 b. MSPR =2, 259, 424, 814 220= 10, 270, 113 9-4 Chapter 10 BUILDING THE REGRESSIONMODEL II: DIAGNOSTICS 10.5. a.
i: 1 2 3 . . . 6 7 8e(Y | X1): −4.475 4.525 −7.475 . . . 2.675 −6.325 5.675 e(X2 | X1): −1 1 −1 . .

. 1 −1 1e(Y | X2): −13.38 −13.13 −16.38 . . . −6.125 −6.375 −3.125 e(X1 | X2y): −3 −3 −3 . . . −1 −1 −1: 9 10 11 . . . 14 15 16et(Y | X1): −3.175 2.825 −.175 . . . −.025 −1.025 4.975 e(X2 | X1): −1 1 −1 . . . 1 −1 1e(Y | X2): 5.625 2.875 8.625 . . . 8.875 16.625 13.875 e(X1 | X2): 1 −1 1 . . .
3 3 3 c. Y (X1) = 50.775 + 4.425X1, X2(X1) = 3 [Y − Y (X1)] = 4.375[X2 − X2(X1)], Y = 37.650 + 4.425X1 + 4.375X2 10.6. a. Y = 3995.48 + .00091916X1 + 12.1205X2 b. i: 1 2 . . . 51 52e(Y | X1): −101.811 108.842 . . .
−279.061 −11.165 e(X2 | X1): −.205 −1.205 . . . .312 .419e(Y | X2): −95.621 152.904 . . .
−184.865 −27.843 e(X1 | X2): 4, 036.66 32, 043.7 . . . 106, 600 −12, 742.4 c.
Y (X1) = 4079.87 + .000935X1, X2(X1) = 6.96268 + .00000135X1 [Y − Y (X1)] = 12.1205[X2 − X2(X1)], Y = 3995.48 + .00091916X1 + 12.1205X2 10.7. a.
i: 1 2 . . . 45 46e(Y | X1, X2): 1.671 −1.680 . . .
−1.967 13.179 e(X3 | X1, X2): −.116 .193 . . . −.265 −.232e(Y | X1, X3): .589 −7.218 . . . −7.365 9.808 e(X2 | X1, X3): −1.077 −4.213 . . . 4.134 .554e(Y | X2, X3): −12.537 −9.734 . . .
−4.086 12.696 e(X1 | X2, X3): 11.081 .573 . . . −1.272 −2.316 10.1 10.8. a. i: 1 2 . . . 80 81et(Y | X1, X2): −.630 −1.768 . . .
−.129 −1.068 e(X3 | X1, X2): −.039 .179 . . . −.016 .016e(Y | X1, X3): −2.085 −2.75065 . . . .116 −.240 e(X2 | X1, X3): −3.491 −1.155 . . . .905 1.950e(Y | X2, X3): −.242 −3.259 . . . −.259 −1.490 e(X1 | X2, X3): −2.405 8.596 . . . 1.437 3.198 10.9. a&g. i: 1 2 3 4 5 6ti: −.041 .061 −1.361 1.386 −.367 −.665 Di: .0002 .0004 .1804 .1863 .0077 .0245 i: 7 8 9 10 11 12ti: −.767 .505 .465 −.604 1.823 .978 Di: .0323 .0144 .0122 .0204 .1498 .0510 i: 13 14 15 16ti: −1.140 −2.103 1.490 .246 Di: .1318 .3634 .2107 .0068 t(.9969; 12) = 3.31. If |ti| ≤ 3.31 conclude no outliers, otherwise outliers. Con-clude no outliers. c. 2p/n = 2(3)/16 = .375, no d.
Xnew = [1 10 3] (X′X)−1 = 1.2375 −.0875X 0.875 −.1875 0.125 0 .0625 hnew,new = .175, no extrapolation e. DFBETASDFFITS b0 b1 b2 D Case 16: −1.174 .839 −.808 −.602 .3634 f. .68% 10.10. a&f. i: 1 2 . . .
51 52ti: −.224 1.225 . . . −1.375 .453 Di: .0003 .0245 . . . .0531 .0015 t(.9995192; 47) = 3.523. If |ti| ≤ 3.523 conclude no outliers, otherwise outliers. Conclude no outliers. b. 2p/n = 2(4)/52 = .15385. Cases 3, 5, 16, 21, 22, 43, 44, and 48. c. Xnew = [1 300, 000 7.2 0] 10-2 (X′X)−1 = 1.8628 −.0000 −.1806 .0473.0000 −.0000 −.0000 .0260
−.0078.1911 hnew, new = .01829, no extrapolation d. DFBETASDFFITS b0 b1 b2 b3 D Case 16: −.554 −.2477 −.0598 .3248 −.4521 .0769Case 22: .055 .0304 −.0253 −.0107 .0446 .0008Case 43: .562 −.3578 .1338 .3262 .3566 .0792Case 48: −.147 .0450 −.0938 .0090 −.1022 .0055Case 10: .459 .3641 −.1044 −.3142 −.0633 .0494Case 32: −.651 .4095 .0913 −.5708 .1652 .0998Case 38: .386 −.0996 −.0827 .2084 −.1270 .0346Case 40: .397 .0738 −.2121 .0933 −.1110 .0365 e. Case 16: .161%, case 22: .015%, case 43: .164%, case 48: .042%, case 10: .167%, case 32: .227%, case 38: .152%, case 40: .157%. 10.11. a&f.i: 1 2 . . . 45 46ti: .0116 −.9332 .
−.5671 1.0449 Di: .000003 .015699 . . . .006400 .024702 t(.998913; 41) = 3.27. If |ti| ≤ 3.27 conclude no outliers, otherwise outliers. Conclude no outliers. b.
2p/n = 2(4)/46 = .1739. Cases 9, 28, and 39. c. Xnew = [1 30 58 2.0] (X′X)−1 = 3.24771 .00922 −.06793 −.06730.00046 −.00032 −.00466 .00239 −.01771.49826 hnew, new = .3267, extrapolation d. DFBETASDFFITS b0 b1 b2 b3 D Case 11: .5688 .0991 −.3631 −.1900 .3900 .0766Case 17: .6657 −.4491 −.4711 .4432 .0893 .1051Case 27: −.6087
−.0172 .4172 −.2499 .1614 .0486 f. Case 11: 1.10%, case 17: 1.32% , case 27: 1.12%. 10.12. a&f.i: 1 2 . . . 80 81ti: −.9399 −1.3926 . . . −1.9232 −.8095 Di: .0117 .0308 . . . .0858 .0046 t(.999938; 75) = 4.05. If |ti| ≤ 4.05 conclude no outliers, otherwise outliers. Conclude no outliers. 10-3 b. 2p/n = 2(5)/81 = .1235. Cases 3, 8, 53, 61, and 65. c.
Xnew = [1 10 12 .05 350, 000] (X′X)−1 = .2584 −.0003 −.0251 −.2508 .0000 −.0004 −.0002 .0031 −.0000 .0001 .0219 −.0000 .9139 −.0000 .0000 hnew, new = .0532, no extrapolation d. DFBETASDFFITS b0 b1 b2 b3 b4 D Case 61: .639 −.0554 .0242 −.0076 .5457 .0038 .0728Case 8: .116 −.0142 −.0072 .0030 .0959 .0126 .003Case 3: −.284 −.2318
−.1553 .2364 .1608 −.0115 .0105Case 53: .525 −.0196 −.0240 −.0243 .4180 .0490 .055Case 6: −.873 .1951 −.5649 −1.7767 −.6182 .4482 .137Case 62: .690 .2758 −.3335 −.2595 .0627 .4051 .088 e. Case 61: .300%, case 8: .054%, case 3: .172%, case 53: .255%, case 6: .417%. 10.13. a. Y = 1.02325 + .96590X1 + .62916X2 + .67603X3 b. H0: β1 = β2 = β3 = 0, Ha: not all βk = 0 (k = 1, 2, 3).
MSR = 127.553,MSE = 3.33216, F* = 127.553/3.33216 = 38.28, F(.95; 3, 10) = 2.84. If F* ≤ 2.84 conclude H0, otherwise Ha. Conclude Ha. c. H0: βk = 0, Ha: βk ≠ 0. t(.975; 10) = 2.021. If |t*| ≤ 2.021 conclude H0, otherwise Ha. b1 = .96569, s{b1} = .70922, t*1 = 1.362, conclude H0 b2 = .62916, s{b2} = .77830, t*2 = .808, conclude H0 b3 = .67603, s{b3} = .35574, t*3 = 1.900, conclude H0 No d. X1 X2 X3 1 .9744 .37061 .4099 1 10.14. a. (V IF)1 = (1 − .95079)−1 = 20.3 (V IF)3 = (1 − .17896)−1 = 1.218 b. Y = 3.16277 + 1.63806X1 10.15. b. (V IF)1 = (V IF)2 = 1.0196, (V IF)3 = 1.0144, (V IF)4 = 1.0144 10.17. b.
(V IF)1 = 1.6323, (V IF)2 = 2.0032, (V IF)3 = 2.0091 10.18. b. (V IF)1 = (1 − .193775)−1 = 1.2403 (V IF)2 = (1 − .393287)−1 = 1.6482 (V IF)3 = (1 − .244458)−1 = 1.3236 (V IF)4 = (1 − .292147)−1 = 1.4127 10.19.a,b&c. i: 1 2 3 · · · 23 24 25ei: 3.308 5.494 −2.525 · · · −.202 .172 2.035 ei (Y | X1): 4.35 8.16 .53 · · · −14.52 27.41 −3.12e(X3 | X1): .57 1.46 1.68 · · · −.785 14.99 −2.88e(Y | X2): −2.63 −8.60 −5.31 · · · −1.15 −5.16 −1.72e(X1 | X2): −.50 −.70 .−.473 −60.6 5.73 · · · −3.87 −15.24 −10.79Exp. value: 4.744 5.590 −2.724 · · · .522 1.050 2.724 10.20. normal, no outlier
r = .983. If r ≥ .939 conclude H0, otherwiseHa. Conclude H0. d and e. i: 1 2 3 · · · 23 24 25hii: .071 .214 .046 · · · .074 .171 .060ti: .645 1.191 −.484 · · · −.039 .035 .392 t(.999; 21) = 3.53. If |ti| ≤ 3.53 conclude no outliers, otherwise outliers. Conclude no outliers. f. DFBETASCase DFFITS b0 b1 b2 b3 D 7 −.340 −.240 −.151 .303 .04016 .603 −.069 .152
.051 .09218 1.000 −.464 .878 .115 .308 g. (V IF)1 = (V IF)2 = 1.034 10.20.a&b. Y = 134.400 − 2.1333X1 + 1.699X2 + .03331X2 i: 1 2 3 · · · 17 18 19ei: 17.740 −1.61 −.616 · · · −7.061 −.582 −8.256 Exp. value: 14.564 5.789 −2.788 · · · −7.467 .000 −11.609 r = .963 c. (V IF)1 = 5.431, (V IF)2 = 11.640, (V IF)3 = 22.474 d&e. i: 1 2 3 · · · 17 18 19hii: .276 .083 .539 · · · .144 .139 .077ti: 2.210 .399 −.629 · · · −.709 −.057 −.802 10-5 t(.9987; 14) = 3.65. If |ti| ≤ 3.65 conclude no outliers, otherwise outliers. Con-clude no outliers. f.
DFBETASCase DFFITS b0 b1 b2 b3 D 3 −.680 −.652 .592 .433 −.482 .1217 1.749 1.454 −1.278 −.742 .848 .4598 −4.780 −1.547 1.187 3.162 −3.286 4.991 15 .175 −.016 −.035 .077 −.016 .008 10.21. a. (V IF)1 = 1.305, (V IF)2 = 1.300, (V IF)3 = 1.024 b&c. i: 1 2 3 · · · 32 33ei: 13.181 −4.042 3.060 · · · 14.335 1.396 e(Y | X2, X3): 26.368 −2.038
−31.111 · · · 6.310 5.845e(X1 | X2, X3): −.330 −.050 .856 · · · .201 .111e(Y | X1, X3): 18.734 −17.470 8.212 · · · −12.566 −8.099 e(X2 | X1, X3): −7.537 18.226 −6.993 · · · 2.401 12.888e(Y | X1, X2): 11.542 −7.756 15.022 · · · 6.732 −15.100 e(X3 | X1, X2): −2.111 −4.784 15.406 · · · −9.793 −21.247Exp.
value: 11.926 −4.812 1.886 · · · 17.591 −.940 10.22. a. Y′ = −2.0427 − .7120X′1 + .7474X′2 + .7574X′3, where Y′ = loge Y, X′1 = loge X1, X′2 = loge(140−X2), X′3 = loge X3 c.
i: 1 2 3 · · · 31 32 33ei: −.0036 .0005 −.0316 · · · −.1487 .2863 .1208 Exp. value: −.0238 .0358 −.0481 · · · −.1703 .2601 .1164 c. (V IF)1 = 1.339, (V IF)2 = 1.330, (V IF)3 = 1.016 d&e. i: 1 2 3 · · · 31 32 33hii: .101 .092 .176 · · · .058 .069 .149ti: −.024 .003 −.218 · · · −.975 1.983 .829 t(.9985; 28) = 3.25. If |ti| ≤ 3.25 conclude no outliers, otherwise outliers. Con-clude no outliers. f. DFBETASCase DFFITS b0 b1 b2 b3 D 28 .739 .530 −.151 −.577 −.187 1.0029 −.719 −.197 −.310 .420 .109 10.23. a. X0 = X(1), Y0 = Y(1) b. h11 = X(1)X0−1 From (10.34), we obtain: b(1)X0 − b(1))X0 pMSE(1) = (b − b(i))X(X0−1)X−1X0 p MSE 10-6 10.24. H = X(X′X)−1X′ = XX−1(X′)−1X′ = II = I hii = 1, Yi = Yi 10.25. MSE(i) = (n − p)SSE n− p− e2 i 1− hii)= (n− p − 1) from (10.25) Substitution into (10.24a) yields (10.26): ti = ei [n− p− 1 SSE(1− hii)− e2i] 1/2 10.26. From Exercise 5.31, σ2(Y) = Hσ2 or σ2(Yi) = σ2hii ; hence ∑σ2(Yi) = σ2 ∑ hii = σ2p by (10.27) 10.27.a&b.
i: 57 58 59 · · · 111 112 113ei: −.086 −.064 −.004 · · · .049 .086 .019 Exp. value: −.077 −.057 .005 · · · −.043 .084 .010 H0: normal, Ha: not normal. r = .990. If r ≥ .980 conclude H0, otherwise Ha. Conclude H0. c. (V IF)1 = 1.065, (V IF)2 = 1.06. 10.28. c. i: 57 58 59 · · · 111 112 113hii: .055 .055 .069 · · · .042 .028 .067ti: −1.617 −1.201 −.079 · · · .911 1.889 .348 t(.9999; 103) = 4.00. If |ti| ≤ 4.00 conclude no outliers, otherwise outliers. Con-clude no outliers.
f. DFBETASCase DFFITS b0 b1 b2 b3 b6 D 62 .116 .010 .007 −.061 .094 .00375 .254 .222 −.242 .069 −.066 .01687 −.411 .025 −.031 .022 −.291 .040 106 .757 −.437 .626 −.400 −.032 .138112 1.200 −.464 .372 .051 1.132 .343 10.28.a&b. 10-7 i: 2 4 6 · · · 436 438 440ei: −.794 .323 4.615 · · · .078 .007 −.008 Exp. value: −1.011 .644 1.011 · · · .249 .052
−.010 H0: normal, Ha: not normal. r = .636. If r ≥ .982 conclude H0, otherwise Ha.Conclude Ha. c. (V IF)1 = 4.5906,(V IF)9 = 4.2859, (V IF)13 = 1.4074, (V IF)14 = 1.0556, (V IF)15 = 1.3357, X6 X8 X9 X13 X14 X15 1 .174 .113 −.025 −.222 .0781 .921 .003 −.0550 .153 .101 1 .173 .034 .1451 .513 −.649 1 −.379 Note: Variable numbers for predictor variables are those in the data set description 10-8 d&e. i: 2 4 6 · · · 436 438 440hii: .514 .090 .095 · · · .063 .041 .007ti: −3.182 .926 31.797 · · · .219 .020 −.021 t(.99989; 412) = 3.759. If |ti| ≤ 3.759 conclude no outliers, otherwise outliers.Conclude case 6 is an outlier. f.DFBETAS Case DFFITS b0 b6 b8 b9 b13 b14 b15 D2 −.403 −.479 −.815 1.184 −.825 1.188 1.4678 −.60 595.06 −.052 .456 −.548 .006 −.488 −.778 .058 65.02 48 .31 134.34 −.079 .290 −.271 .088 −.215 .030 .014128 −.10 170.05 −.003 −.014 .023 −.093 −.222 −.038 .001266 .20 −399.49 −.056 .030 .0005 .157 −.142 −.275 .006404 −.12 220.73 −.019 −.011 .018 −.001 −.654 −.028 .002 6 10.29 −8536.94
−274 −4.236 6.678 2.279 5.196 2.10 2.634 10-8 Chapter 11 BUILDING THE REGRESSIONMODEL III: REMEDIALMEASURES 11.6. a. Y = 19.4727 + 3.2689X c. i: 1 2 3 4 5 6ei: 5.225 4.763 6.389 −2.162 −3.237 −5.044 i: 7 8 9 10 11 12ei: 2.838 1.032 6.418 −1.700 2.687 −4.431 b. n1 = 6, d1 = 2.821, n2 = 6, d2 = 4.833, s = 1.572, t∗BF = (2.821 −
4.833)/1.572 √1/6 + 1/6) = −2.218, t(.975; 10) = 2.228. If |t∗BF | ≤ 2.228 conclude error variance constant, otherwiseerror variance not constant. Conclude error variance constant. d. s = −905 + .3226X; smallest weight = .02607, case 3; largest weight = .18556,cases 4 and 7. e.
Y = 17.3006 + 3.4211X f. s{b0}:s{b1}: Unweighted Weighted5.5162 4.8277.3651 .3703 g. Y = 17.2697 + 3.4234X 11.7. a. Y = −5.750 + .1875X i: 1 2 3 4 5 6ei: −3.75 5.75 −13.50 −16.25 −9.75 7.50 i: 7 8 9 10 11 12ei: −10.50 26.75 14.25 −17.25 −1.75 18.50 b. SSR∗ = 123, 753.125, SSE = 2, 316.500, 11-1 X2BP = (123, 753.125/2)/(2, 316.500/12)2 =
1.66, χ2(.90; 1) = 2.71. If X2 BP ≤ 2.71 conclude error variance constant, otherwise error variance not constant.
Concludeerror variance constant. d. v = −180.1 + 1.2437X i: 1 2 3 4 5 6weight: .01456 .00315 .00518 .00315 .01456 .00518 i: 7 8 9 10 11 12weight: .00315 .01456 .00315 .01456 .00518 e. Y = −6.2332 + .18911X f. b. s{b0}:s{b1}: Unweighted Weighted16.7305 13.1672 .0538 .0506 g. Y = −6.2335 + .18911X 11.8. b. Y = 31.4714 + 10.8120X1 + 22.6307X2 + 1.2581X3 + 2.8523X4 i: 1 2 3 · · · 63 64 65ei: −3.2892 −3.2812 −3274 · · · 36.9093 −18.6811 −5.3643 c. n1 = 33, d1 = 2.7595, n2 = 32, d2 = 10.1166, s = 6.3643, t∗BF = (2.7595− 10.1166)/(6.3643 √1/33 + 1/32)= −4.659, t(.995; 63) = 2.656. If |t∗BF| ≤ 2.656 conclude error variance constant, otherwiseerror variance not constant.
Conclude error variance not constant.
e. s = 2.420 + .3996X3 + .2695X4 i: 1 2 3 · · · 63 64 65weight: .0563 .0777 .0015 · · · .0484 .0041 .0035 f. Y = 29.4255 + 10.8996X1 + 26.6849X2 + 1.4253X3 + 1.7239X4 g. s{b0}:s{b1}:s{b2}:s{b3}:s{b4}: Unweighted Weighted2.8691 1.36173.2183 1.49183.4846 1.6686.2273 .2002.2276 .3206 h. Y = 29.0832 + 11.0075X1 + 26.8142X2 + 1.4904X3 + 1.6922X4 11.9. b. c = .06: c. Y = .410X∗1 + .354X∗2 + .165X∗3 Y = 21.7290 + 1.7380X1 + .17272X2 + .69293X3 11.10. a. Y = 3.32429 + 3.76811X1 + 5.07959X2 11-2 d. c = .07 e. Y = 6.06599 + 3.84335X1 + 4.68014X2 11.11. a. Y = 1.88602 + 15.1094X (47 cases) Y = −.58016 + 15.0352X (45 cases) b. i: 1 2 . . . 46 47 ui: −1.4123 −.2711 . . . 4.6045 10.3331 (smallest weights: .13016 (case 47), .29217 (case 46) c. Y = −.9235 + 15.13552X d. 2nd iteration: Y = −1.535 + 15.425X 3rd iteration: Y = −1.678 + 15.444X smallest weights: .12629 (case 47), .27858 (case 46) 11.12. a. Y = −193.924 + 5.248X b.
smallest weight: .5582 (case 2) c. Y = −236.259 + 5.838X d. 2nd iteration: Y = −241.577 + 5.914X 3rd iteration: Y = −242.606 + 5.928X smallest weight: .5025 (case 2) 11.13. Q= ∑ [Xki (Yi − β0 − β1Xi)2 ∂Q∂β0 = −2∑ 1 Xki (Yi − β0 − β1Xi) ∂Qw ∂β1 = −2∑ 1 Xki (Yi − β0 − β1Xi) Setting the derivatives equal to zero, simplifying, and substituting the least squares estimators b0 and b1 yields: ∑ Yi Xi − b0 ∑1 Xi − nb1 = 0 ∑ Yi − nb0 − b1 ∑ Xi = 0 11.14. b= (X′WX)−1X′WY ; Xw= X′2 σ2{bw}= (X′WX)−1X′W σ2{Y}W′X(X′WX)−1 = (X′WX)−1 X′W σ2{Y}WX(X′WX)−1 11-3 Xw2 = σ2wX{(X′X)−1X′}σ2{Y} = σ2I X(X′X)−1
X4/.11.18. bw = (X′WX)−1X′WY and E{bw} = E[(X′WX)−1X′W][(X′WX)−1X′W]′ = (X′WX)−1X′W[(X′WX)−1X′W]′(1) (since (X′WX)−1 is symmetric) = k(X′WX)−1X′WX(X′WX)−1 (since W is symmetric) = k(X′WX)−1 11.19. E{bR − β}2 = E{bR − E{bR} + E{bR} − β}2 = E{bR − E{bR}}2 + 2E{bR − E{bR}}[E{bR} − β] + E{bR − β}2 =
σ2{bR}+ 0 + [E{bR} − β]2 11.20. a. 38.3666 b. 38.5822, yes. 11.21. a.X: 10 20 30 40 50 E{Y}: 120 220 320 420 520 c. Ordinary least squares: E{b1} = 10, σ2{b1} = .024 Weighted least squares: E{b1} = 10, σ2{b1} = .01975 11.22. a. c (V IF)1 (V IF)2 (V IF)3 b1 b2 b3 .00 1.6323 2.0032 2.0091 .68219 .005 1.6000 1.9506 1.9561 .68218 .010 1.5687
1.9002 1.9054 .68215 .020 1.5098 1.8051 1.8101 .68208 .030 1.4557 1.7222 1.7264 .68201 .040 1.4060 1.6488 1.6529 .68194 .050 1.3600 1.5834 1.5873 .68186 .080 1.2416 1.4284 1.4355 .68155 .100 1.1780 1.3447 1.3482 .68133 .200 1.0084 1.0776 1.0799 .67901 c = .030 11.23. b. c (V IF)1 (V IF)2 (V IF)3 .00 1.2403 1.6482 1.3236 .5907 −1.0044 −.1480 −.2700 −.5540 .1520 −.3010 −.2321 −.0870 −.1560 −.5000 −2.0007 −.0880 −.2331 .040 −.1130 −.2337 .020 −.5687 −.1200
−.2329 .050 −.5553 −.2353 .1231 .030 −.5568 −.1235 −.2328 11.24. a. Y = 62.4054 + 1.5511X1 + .51022X2 + .1019X3 − .1441X4 b. c (V IF)1 (V IF)2 (V IF)3 (V IF)4 b1 b2 b3 b4 .000 38.496 254.423 46.868 282.513 .9824 .002 9.844 51.695 11.346 57.092 .9823 .004 5.592 21.903 6.089 23.971 .9822 .006 4.020 12.210 4.069 13.251 .9821 .008 3.225 7.966 3.212 8.513 .9820
.010 2.747 5.678 2.763 5.988 .9819 .020 1.730 2.024 1.672 2.037 .9818 .040 1.106 1.031 1.073 1.029 .9817 .060 .8543 .5857 .5531 .5519 .9816 .8533 .5584 .5617 .6254 .5519 .0000 .03 .1045 .02 .0513 .06 .0004 .5529 .5570
.020 .4975 .3033 −.0694 −.3942 .040 .4751 .2986 −.0868 −.3920 .080 .4429 .2992 −.1074 −.3873 .100 .4309 .2998 −.1157 −.3824 11.25. a. Y = 50.3840 − 7620X1 − .5300X2 − .2929X3 11.26. a. t(.975; 10) = 2.228, bw1 = 3.4211, s{bw1} = .3703, 3.4211± 2.228(.3703), 2.5961 ≤ β1 ≤ 4.2461 11.27.
a. t(.95; 10) = 1.8125, bw1 = .18911, s{bw1} = .05056, 1.8125(.05056), .09575 ≤ β1 ≤ .2808 11-5 11.28. a. Y = 38.64062 + .33143x− .09107x2, R2 = .9474 b. X = 47.5, b1 = .331429, b11 = −.091071, Xmax = 47.5− [.5(.331429)/(−.091071) = 49.3196 Yh = 38.640625 + .331429(Xmax − 47.5)− .091071(Xmax − 47.5)2 = 38.942 11.29 a.
First split point at X = 57, SSE = 5108.14 b.
Second split point at X = 66, SSE = 4148.76 c. Third split point at X = 38, SSE = 3511.66 11.30 a. First split point at X = 37, SSE = 6753.62 b. Second split point at X = 30, SSE = 3563.79 11-6 Chapter 12 AUTOCORRELATION IN TIMESERIES DATA 12.1. a. t: 1 2 3 4 5 6 7 8 9 10 ct: .30 3.05 2.8 3.1 3.1 .8 −1.1 .9 −1.2 −1.0 −1.1 ct−1: 3.0 3.5 2.8 3.1 3.1 .8 −1.1 .9 −1.2 −1.0 1.0 t: 1 2 3 4 5 6 7 8 9 10ut: .5 −.7 .3
−2.3 −1.9 .2 −.3 .2 ct−1: 3.0 3.5 2.8 3.1 3.1 .8 −1.1 .9 −1.2 −1.0 12.2. Yes. 12.5. (1) H0 : ρ = 0, Ha : ρ > 0. D = .606, dL = 1.10, dU = 1.37. If D > 1.37 conclude H0, if D < 1.10 conclude Ha, otherwise the test is inconclusive. Conclude Ha. (2) H0 : ρ = 0, Ha : ρ > 0. D = 1.45, dL = 1.45, dU = 1.45 and 4 − D > 1.45,conclude H0, if D < 1.12 or 4 − D < 1.12 conclude Ha, otherwise the test isinconclusive. (2) H0 : ρ = 0, Ha : ρ < 0. dL = 1.32, dU = 1.66. If 4 − D > 1.66 conclude H0, if4−D < 1.32 conclude Ha, otherwise the test is inconclusive. (3) H0 : ρ = 0, Ha : ρ > 0. dL = 1.08, dU = 1.36. If D > 1.36 conclude H0,if D < 1.08 conclude Ha, otherwise the test is inconclusive. Conclude H0. 12.6. H0 : ρ = 0, Ha : ρ > 0. D = 2.4015, dL = 1.29, dU = 1.38. If D > 1.38 conclude H0, if D < 1.29 conclude Ha, otherwise the test is inconclusive. Conclude H0. 12.7 H0 : ρ = 0, Ha : ρ > 0. D = 2.2984, dL = 1.51, dU = 1.59. If D > 1.59 conclude H0, if D < 1.51 conclude Ha, otherwise the test is inconclusive. Conclude H0.
12.8. H0 : ρ = 0, Ha : ρ > 0.
D = 2.652, dL = .83, dU = 1.52. If D > 1.52 conclude H0, ifD < .83 conclude Ha, otherwise the test is inconclusive. Conclude H0.
12.9. a. Y = −7.7385 + 53.9533X, s{b0} = 7.1746, s{b1} = 3.5197 t: 1 2 3 4 5 6 7 8et: −.0737 −.0709 .5240 .5835 .2612 −.5714 −1.9127 −.8276 12-1 t: 9 10 11 12 13 14 15 16et: −.6714 .9352 1.803 .4947 .9435 .3156 −.6714 −1.0611 c. H0 : ρ = 0, Ha : ρ > 0. D = .857, dL = 1.10, dU = 1.37. If D > 1.37 conclude H0,if D < 1.10 conclude Ha, otherwise the test is inconclusive. Conclude Ha. 12.10. a. r = .5784, 2(1− .5784) = .8432, D = .857 b. b′0 = −.69434, b′1 = 50.93322 Y′ = −.69434 + 50.93322X′ c. s{b′0} = 3.75590, s{b′1} = 4.34890 c. H0 : ρ = 0, Ha : ρ > 0. D = 1.476, dL = 1.08, dU = 1.36. If D > 1.36 concludeH0, if D < 1.08 conclude Ha, otherwise the test is inconclusive. Conclude H0. d. Y = −1.64692 + 50.93322X s{b0} = 9.00868, s{b1} = 4.34890 f.
F17 = −1.64692 + 50.93322(2.210) + .5784(−.6595) = 110.534, s{pred} = .9508,t(.975; 13) = 2.160, 110.534± 2.160(.9508), 108.48 ≤ Y17(new) ≤ 112.59 g. t(.975; 13) = 2.160, 50.93322± 2.160(4.349), 41.539 ≤ β1 ≤ 60.327. 12.11. a.ρ: .1 .2 .3 .4 .5 SSE: 11.5073 10.4819 9.6665 9.0616 8.6710 ρ: .6 .7 .8 .9 1.0SSE: 8.5032 8.5718 8.8932 9.4811
10.3408 ρ = .6 b. Y′ = −.5574 + 50.8065X′, s{b0} = 3.5967, s{b1} = 4.3871 c. H0 : ρ = 0, Ha : ρ > 0. D = 1.499, dL = 1.08, dU = 1.36. If D > 1.36 concludeH0, if D < 1.08 conclude Ha, otherwise the test is inconclusive. Conclude H0. d. Y = −1.3935 + 50.8065X, s{b0} = 8.9918, s{b1} = 4.3871 f. F17 = −1.3935+50.8065(2.210)+.6(−.6405) = 110.505 12-2 s{pred} = .9467, t(.975; 13) = 2.160, 110.505± 2.160(.9467), 108.46 ≤ Y17(new) ≤ 112.55 12.12. a. b1 = 49.80564, s{b1} = 4.77891 b.
H0 : ρ = 0, Ha : ρ ≠ 0. D = 1.75 (based on regression with intercept term),dL = 1.08, dU = 1.36.
If D > 1.36 and 4−D > 1.36 conclude H0, if D < 1.08 or4−D < 1.08 conclude Ha, otherwise the test is inconclusive. Conclude H0. c. Y = .71172 + 49.80564X, s{b1} = 4.77891 e. F17 = .71172 + 49.80564(2.210) − .5938 = 110.188, s{pred} = .9078, t(.975; 14) = 2.145, 110.188± 2.145(.9078), 108.24 ≤ Y17(new) ≤ 112.14 f.
t(.975; 14) = 2.145, 49.80564± 2.145(4.77891), 39.555 ≤ β1 ≤ 60.056 12.13.
a. Y = 93.6865 + 50.8801X, s{b0} = 8.2299, s{b1} = .2634 t: 1 2 3 4 5 6 7et: −5.5552 −.2471 −.1526 −.2078 .3349 .6431 .2557 12-2 t: 8 9 10 11 12 13 14et: .5610 −.4949 −.6824 .0747 −.0817 −.2336 −1.0425 t: 15 16 17 18 19 20et: −.0299 .5671 .8066 .1203 .5750 .7294 c. H0 : ρ = 0, Ha : ρ > 0. D = .974, dL = .95, dU = 1.15. If D > 1.15 conclude H0, if D < .95 conclude Ha, otherwise the test is inconclusive. The test is inconclusive. 12.14. a. r = .3319, 2(1− .3319) = 1.3362, D = .974 b. b′0 = 63.5840, b′1 = 50.5470 Y′ = 63.5840 + 50.5470X′ c. s{b′0} = .2622 c. H0 : ρ = 0, Ha : ρ > 0. D = 1.13, dL = .93, dU = 1.13. If D > 1.13 conclude H0,if D < .93 conclude Ha, otherwise the test is inconclusive. Conclude H0. d. Y = 94.8720 + 50.5470X s{b0} = .8370, s{b1} = .2622 f. F21 = 94.8720 + 50.5470(3.625) + .3319(.7490) = 278.3535, s{pred} = .4743,t(.995; 17) = 2.898, 278.3535± 2.898(.4743), 276.98 ≤ Y21(new) ≤ 279.73 g. t(.995; 17) = 2.898, 50.5470± 2.898(.2622), 49.787 ≤ β1 ≤ 51.307 12.15. a.ρ: .1 .2 .3 .4 .5 SSE
4.0450 3.7414 2.5511 3.4685 3.4889 ρ: .6 .7 .8 .9 1.0SSE: 3.6126 3.8511 4.2292 4.7772 5.5140 ρ = .4 b. Y′ = 57.04056 + 50.49249X′, s{b0} = .33287, s{b1} = .27697 c. H0 : ρ = 0, Ha : ρ > 0. D = 1.905, dL = .93, dU = 1.13. If D > 1.13 conclude H0,if D < .93 conclude Ha, otherwise the test is inconclusive. Conclude H0. d. Y = 95.0676 + 50.49249X, s{b0} = .88812, s{b1} = .27697 f. F21 = 95.0676+50.49249(3.625)+.4(.7506) = 278.403, s{pred} = .4703, t(.995; 17) = 2.898, 278.403± 2.898(.4703), 277.04 ≤ Y21(new) ≤ 279.77 g. t(.995; 17) = 2.898, 50.49249± 2.898(.27697), 49.690 ≤ β1 ≤ 51.295 12.16. a. b1 = 50.16414, s{b1} = .22376 b. H0 : ρ = 0, Ha : ρ ≠ 0. D = 2.25 (based on regression with intercept term),dL = .93, dU = 1.13. If D > 1.13 and 4 − D > 1.13 conclude H0, if D < .93 or4−D < .93 conclude Ha, otherwise the test is inconclusive. Conclude H0. c. Y = 95.88984 + 50.16414X, s{b1} = .42496 e. F21 = 95.88984+50.16414(3.625)+.1116 = 278.851, s{pred} = .5787, t(.995; 18) = 2.878, 278.851±
2.878(.5787), 277.19 ≤ Y21(new) ≤ 280.52 f. t(.995; 18) = 2.878, 50.16414± 2.878(.22376), 49.51 ≤ β1 ≤ 50.81 12-3 12.17 a. Positive b. Y = −1.43484 + .17616X, s{b0} = .24196, s{b1} = .00163222 c.t: 1 2 3 4 5 6 7 et: −.0307 −.0664 .0180 .1593 .0428 .0029 .0582 t: 8 9 10 11 12 13 14et: −.0613 −.0969 −.1517 −.1501 −.0754 −.0249 .1043 t: 15 16 17 18 19 20et: .1844 .1054 .0289 .0422 −.0439 −.0852 d. H0 : ρ = 0, Ha : ρ > 0. D = .663, dL = .95, dU = 1.15. If D > 1.15 conclude H0,if D < .95 conclude Ha, otherwise the test is inconclusive.
Conclude Ha. 12.18. a. r = .67296, 2(1− .67296) = .65408, D = .663 b. Y′ = −.29235 + .17261X′, s{b′0} = .17709, s{b′1} = .00351. c. H0 : ρ = 0, Ha : ρ > 0.
D = 1.364, dL = .93, dU = 1.13. If D > 1.13 conclude H0,if D < .93 conclude Ha, otherwise the test is inconclusive. Conclude H0. d. Y = −.89390 + .17261X, s{b0} = .54149, s{b1} = .00351 f. F21 = −.89390 + .17261(180) + .67296(−.015405) = 30.338, s{pred} = .09155,t(.95; 17) = 1.740, 30.338± 1.740(.09155), 30.179 ≤ Y21(new) ≤ 30.497. g.
t(.95; 17) = 1.740, .17261± 1.740(.00351), .1665 ≤ β1 ≤ .1787. 12.19. a.ρ: .1 .2 .3 .4 .5 SSE: .1492 .1318 .1176 .1064 .09817 ρ: .6 .7 .8 .9 1.0 SSE: .09275 .08978 .08857 .08855 .09433 ρ = .9 b. Y′ = .04644 + .16484X′, s{b′0} = .05692, s{b′1} = .01230, s{b1} = .006538 c. H0 : ρ = 0, Ha : ρ > 0. D = 1.453, dL = .93, dU = 1.13.
If D > 1.13 conclude H0,if D < .93 conclude Ha, otherwise the test is inconclusive. Conclude H0. d. Y = .4644 + .16484X, s{b0} = 1.1230, s{b1} = .006538 f. F21 = .4644+.16484(180)+.9(−.26888) = 30.267, s{pred} = .09545, t(.95; 17) = 1.740, 30.267± 1.740(.09545), 30.101 ≤ Y21(new) ≤ 30.433 g. t(.95; 17) = 1.740, .16484± 1.740(.01230), .1535 ≤ β1 ≤ .1762 12.20. a. b1 = .16883, s{b1} = .004566 b. H0 : ρ = 0, Ha : ρ ≠ 0. D = 1.480 (based on regression with intercept term), dL = .93, dU = 1.13. If D > 1.13 and 4 − D > 1.13 conclude H0, if D < .93 conclude Ha, otherwise the test is inconclusive. Conclude H0. c. Y = −.35222 + .16883X, s{b1} = .004566 e. F21 =
.0942 + 30.300, s{pred} = .0901, t(.95; 18) = 1.734, 30.300± 1.734(.0901), 30.144 ≤ Y21(new) ≤ 30.456 f. t(.95; 18) = 1.734, .16883± 1.734(.004566), .1609 ≤ β1 ≤ .1768 12.22. c2(ρ) = 1 + ρ2 + 2ρ ≥ 1 ... E{ct ut−1} = E{ut + ρut−1 + ... }... E{ut} = 0 ... [illegible]
a. n = 1 c(Y) = .90 c. r2 (n − 2) ... 12-5 ... (β1 − ρβ0) ... Set equal ... 12-6 ... 12.25 ... 12.26 ... Then: Fn+1 = Yn+1 + r1en + r2en−1 where r1 and r2 are point estimates of ρ1 and ρ2, respectively, obtained by either theCochrane-Orcutt procedure or the Hildreth-Lu procedure. 12.27. c. E{b1} = 24 even in presence of positive autocorrelation. 12-6 Chapter 13 INTRODUCTION TO NONLINEARREGRESSION AND NEURALNETWORKS 13.1. a. Intrinsically linear loge f(X, γ) = γ0 + γ1X b. Nonlinear. c. Nonlinear 13.2. a. Intrinsically linear f(X, γ) = γ0 + γ1 loge X b. Intrinsically linear loge f(X, γ) = loge γ0 + γ1 loge X + γ2 loge X2 c. Nonlinear 13.3. b. 300, 3.7323 13.4. b. 49, 2.2774 13.5. a. b0 = .5072512, b1 = −0.006934571, g(0)0 = 0, g (0)1 = .000693457, g (0)2 = .6021485 b. g0 = .04823, g1 = .00112, g2 = .71341 13.6. a. Y = .04823 + .71341exp(−.00112X) City Ai: 1 2 3 4 5 Yi: .61877 .50451 .34006 .23488 .16760ei: .01123 −.04051 .00494 .02512 −.00536 Exp.
value: .00125 −.04125 −.00180 .02304 .00180 i: 6 7 8 Yi: .12458 .07320 .05640ei: .02542 −.01320 −.01640 Exp. value: .02989 −.01777 −.02304 13-1 City Bi: 9 10 11 12 13 Yi: .61877 .50451 .34006 .23488 .16760ei: .01123 −.00451 −.04006 .00512 .00240 Exp. value: .01327 −.00545 −.02989 .00545 .01777 i: 14 15 16 Yi: .12458 .07320 .05640ei:
−.00458 .00680 −.00640 Exp. value: −.00923 .00923 −.01327 13.7. H0 : E{Y} = γ0 + γ2 exp(−γ1X), Ha : E{Y} ≠ γ0 + γ2 exp(−γ1X). SSPE = .00290, SSE = .00707, MSPE = .00290/8 = .000363, MSLF = (.00707 − .00290)/5 = .000834, F∗ = .000834/.0003625 = 2.30069,F(.99; 5, 8) = 6.6318. If F∗ ≤ 6.6318 conclude H0, otherwise Ha.
Conclude H0.
13.8. s{g0} = .01456, s{g1} = .000092, s{g2} = .02277, z(.9833) = 2.128 .04823± 2.128(.01456), .01725 ≤ γ0 ≤ .07921 .00112± 2.128(.000092), .00092 ≤ γ1 ≤ .00132 .71341± 2.128(.02277), .66496 ≤ γ2 ≤ .76186 13.9. a. g0 = .04823, g1 = .00112, g2 = .71341, g3 = .00250 b. z(.975) = 1.96, s{g3} = .00121, −.00250 ± 1.96(.0121), −.00225 ≤ γ3 ≤ .00475, yes, no. 13.10. a. 13-2 Y = 34.3738 + ... 28.13705X1 1+ ... 27.2(X/13.5)2 ... Cases ... 13.11 ... 100.3401 ... 13.12 ...
a.
Y = 100.3401−100.3401/[1 + (X/48.1515)2.7661] i: 1 2 3 4 5 6 Yi: .0038 .3364 4.4654 11.2653 11.2653 23.1829 29.182999 ... Exp. value: −.3928 1.6354 −2.7576 ... 13.12. b. 16.7 ... 13.13 ...
SSPE = 8.67999, SSE = 35.71488, MSPE = 8.67999/6 = 1.4467, MSLF = (35.71488− 8.67999)/10 = 2.7035, F∗ = 2.7035/1.4467 = 1.869,F(.99; 10, 6) = 7.87. If F∗ ≤ 7.87 conclude H0, otherwise Ha. Conclude H0.
13.16. s{g0} = 1.1741, s{g1} = .1943, s{g2} = .02802, z(.985) = 2.17 100.3401± 2.17(1.1741) 97.7923 ≤ γ0 ≤ 102.8879 6.4802± 2.17(.1943) 6.0586 ≤ γ1 ≤ 6.9018 4.8155± 2.17(.02802) 4.7547 ≤ γ2 ≤ 4.8763 13.17.
a. b0 = 98.187, b1 = −.51485, b2 = .29845, g(0)0 = 0, g(0)1 = −.29845 b. g0 = 10.0797, g1 = .49871, g2 = .30199 13.18.
a.
Y = 10.0797X .498711 X .30199 2 b. i: 1 2 3 4 5 6 Yi: 14.8212 ... 13.19 ... 13.20 ... E{Y} = γ0X γ1 ... 13.21 ...
(Setting the derivatives equal to zero, simplifying, and substituting the least squares estimators g0, g1 and g2 yields ... 13.22 ... 13.23 ... 13.24 ... 13.25 ... 13.26 ... 13.27 ... 13.28 ... 13.29 ... 13.30 ... 13.31 ... 13.32 ...)
14.6. a. Y = .1386 + .0004X ... 14.7 ... 14.8 ... 14.9 ... 14.10 ... 14.11 ... 14.12 ...
H0: β1 = 0, Ha: β1 ≠ 0. ... conclude H0, otherwise Ha. Conclude Ha. P-value = 0+. ...
14.13 ... 14.14 ... 14.15 ... 14.16 ... 14.17 ... 14.18 ... 14.19 ... 14.20 ...
d. H0 : β3 = 0, Ha : not all βk = 0, for k = 3, 4, 5. G2 = 1.534,χ2(.95; 3) = 7.81. If G2 ≤ 7.81, conclude H0, otherwise conclude Ha. ConcludeH0. 14.21. a. X1 enters in step 1; no variables satisfy criterion for entry in step 2. b. X2 is deleted in step 2; X1 is deleted in step 3; X2 is deleted in step 4; X1 is retained in the model. c.
The best model according to the AICp criterion is based on X1 and X2. AIC3 =42.6896. d. The best model according to the SBCp criterion is based on X1. SBC2 = 46.2976. 14.22. a. X1 enters in step 1; X2 enters in step 2; no variables satisfy criterion for entry in step 3. b.
X11 is deleted in step 1; X12 is deleted in step 2; X3 is deleted in step 3; X1 and X2 are retained in the model.
c. The best model according to the AICp criterion is based on X1 and X2. AIC3 =111.795. d. The best model according to the SBCp criterion is based on X1 and X2. SBC3 =121.002. 14.23. ... 14.24 ... 14.25 ... 14.26 ... 14.27 ... 14.28 ... 14.29 ... 14.30 ... 14.31 ... 14.32 ... 14.33 ... 14.34 ... 14.35 ... 14.36 ... 14.37 ... 14.38 ... 14.39 ... 14.40 ... 14.41 ... 14.42 ... 14.43 ...
Formula (14.26) holds for given observations Y1, Y2,... Yn. Assembling all terms with a given X value, Xj, we obtain: yj[β0 + β1Xj] − loge[1 + exp(β0 + β1Xj)] since there are nj cases with X value of Xj, of which y.j have value Yi = 1. There are(nj y.j)ways of obtaining these y.j 1s out of nj, all of which are equally likely. Hence, in the log-likelihood function of the yj, we must add loge (nj y.j) to the above term for given Xj: loge (nj y.j) + y.j [β0 + β1Xj] − nj loge [1 + exp(β0 + β1Xj)] Assembling the terms for all Xj, we obtain (14.34). 14.42. From (14.16) and (14.18), we have: 1 − π = [1 + exp(π′)]−1 Hence (π 1 − π) = exp(π′) [1 + exp(π′)]−1 = exp(π′) Solving for π′ = F−1L (π) by taking logarithms of both sides yields the result. 14.43. From (14.26), we obtain: ∂loge L ∂β0 = −n∑ i=1 Yi − n∑ i=1 exp(β0 + β1Xi) 1 + exp(β0 + β1Xi) ... Since these partial derivatives involve the constants X, β0, and β1, the expecta-tions of the partial derivatives are themselves.
Hence: ... the stated matrix reduces to (14.51).
14.44. ... 14.45 ... 14.46 ... 14.47 ... 14.48 ... 14.49 ... 14.50 ... 14.51 ... 14.52 ... 14.53 ... 14.54 ... 14.55 ... 14.56 ... 14.57 ... 14.58 ... 14.59 ... 14.60 ...
Model.
c. Retain socioeconomic status and age. 14.49. a. j: 1 2 3 4 5Oj1: ... Conclude H0. ... Cutoff Savings Account ...
H0 : β2 = β3 = 0, Ha : not all βk = 0, for k = 2, 3. G2 = 1.534 ... χ2(.95; 2) = 5.99. If G2 ≤ 5.99, conclude H0, otherwise conclude Ha. Conclude H0. ...
Retain age and relative daily census. 14-11 d. The best subset: X3, X6, X10, AIC4 = 59.6852; The best subset: X10, SBC2 = 66.963. 14.52. a. ... Conclude H0. P-value = 0.01. ...
14.57 ... 14.58 ... 14.59 ... 14.60 ... 14.61 ... 14.62 ... 14.63 ... 14.64 ... 14.65 ...
Regression Coefficient Estimates Label Estimate Std. Error Constant 0.499446 0.176041 Cost 0.000149508 2.854645E-6 Age 0.00672387 0.00296715 Gender 0.181920 0.0439932 Interventions 0.0100748 0.00380812 Drugs 0.193237 0.0126846 14-17 Complications 0.0612547 0.0599478 Comorbids −0.000899912 0.00368517 Duration 0.000323019 .0004 14-18 Chapter 15 INTRODUCTION TO THE DESIGNOF EXPERIMENTAL ANDOBSERVATIONAL STUDIES 15.7. Panel. 15.8. a. Mixed. Type of instruction is an experimental factor, and school is an observationalfactor.
. b. Factor 1: type of instruction, two levels (standard curriculum, computer-basedcurriculum). Factor 2: school, three levels. Randomized complete blocked design. d. Section. 15.9. a. Observational. b.
Factor: expenditures for research and development in the past three years. Factor levels: low, moderate, and high. c. Cross-sectional study. d. Firms. 15.10. a. Mixed. Color of paper is experimental factor, and parking lot is an observationalfactor. b. Factor 1: color of paper, three levels (blue, green, orange). Factor 2: supermarket parking lot, four levels. d. Randomized complete blocked design. d. Car. 15.11. a. Observational. b. Fitness status, three levels (below average, average, above average). c. Cross-sectional study. d. Person 15.12. a. Mixed. Applicant's eye contact is an experimental factor, and personnel officer'sgender is an observational factor. b. Factor 1: applicant's eye contact, two levels (yes, no). Factor 2: personnel officer's gender (male, female). c. Randomized complete blocked design. d. Personnel officer. 15.13. a. Mixed. b.
Wheel.
c. Four rubber compounds. d. Randomized complete blocked design. e. Balanced incomplete blocked design. 15.14. a. Experimental. b.
Factor 1: ingredient 1, with three levels (low, medium, high). Factor 2: ingredient 2, with three levels (low, medium, high). There are 9 factor-level combinations. d. Completely randomized design. e.

Volunteer. 15.15. a. Observational. b. Factor 1: treatment duration, with 2 levels (short, long). Factor 2: weight gain, with 3 levels (slight, moderate, substantial) c. Cross-sectional study. d. Patient. 15.16. a. Mixed. b. Factor: questionnaire, with 3 levels (A, B, C). c. Repeated measure design. d. Subject-time combination (i.e., the different occasions when a treatment is appliedto a subject). 15.17. a. Observational. b. Factor 1: batch, with 5 levels. Factor 2: barrel, with 4 levels (nested within batch). c. Nested design. d. Barrel. 15-2 15.18. a. Experimental. b. Factor 1: poly-film thickness, with 2 levels (low, high). Factor 2: old mixture ratio, with 2 levels (low, high). Factor 3: operator glove type, with 3 levels (cotton, nylon). Factor 4: underside oil coating, with 2 levels (no coating, coating). c. Fractional factorial design. d. 1000 moldings in a batch. 15.19. a. Randomized complete block design with four blocks and three treatments. c. Assembler. 15.20. a. 23 factorial design with two replicates. c. Rod. 15.23. a. H0: W = 0, Ha: W ≠ 0.

t* = −.19(15/.0112 = −17.10, t(.975, 19) = 2.093, If|t*| ≤ 2.093 conclude H0, otherwise conclude Ha. Conclude Ha. P -value = 0+ b. ... 16.1. a. H0: β2 = 0, ... Under H0 ... F* = [(.23586 − .023828)/(38 − 19)] ÷ [.023828/19] = 8.90, F (.95; 19, 19) = 2.17. If F* > 2.17 conclude H0, otherwise conclude Ha. Conclude H0. P -value = 0+ Not of primary interest because blocking factor was used here to increase theprecision. 15.24. Since X = n/2n = 1/2, it follows from the definition of Xi that∑(Xi − X) = n(2/1 − 1/2)2 + n(0 − 1/2)2 = 4n/2n. Then from (15.5a): σ2{b1} = 4σ2/n. 15-3 15-4 Chapter 16 SINGLE-FACTOR STUDIES 16.4. b. E{MSTR} = 9 + 25(450) 2 = 5, 634 E{MSE} = 9 16.5. b. E{MSTR} = (2.8)2 + 100(11)3 = 374.507 E{MSE} = 7.84 c. E{MSTR} = (2.8)2 + 100(15.6)3 = 523.173 16.7. b. Y1. = 6.87778, Y2 = 8.13333, Y3 = 9.20000 c. eij: ... 16.8. b. Y1. = 24.0 c. Source SS df MSBetween levels 20.125 2 10.0625Error 15.362 24 .6401Total 35.487 26 e. H0: all μi are equal (i = 1, 2, 3), Ha: not all μi are equal. F * = 10.0625/.6401 =15.720, F (.95; 2, 24) = 3.40. If F * ≤ 3.40 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ 16.9. b. Y1. = 38.0, Y2 = 32.0, Y3 = 24.0 c. eij: ... Source SS df MSBetween designs 1, 008.0 2 ... If F* ≤ ... conclude H0, otherwise Ha. Conclude Ha. P -value = 0+

F * = 336.00/19.81 = 16.96, F (.99; 2, 21) = 5.78. If F * ≤ 5.78 conclude H0, otherwise Ha. ConcludeHa. f. P -value = 0+ 16.10. b. Y1 = 21.500, Y2 = 27.750, Y3 = 21.417 c. eij: ... Source SS df MSBetween ages 316.722 2 158.361Error 82.167 33 2.490Total 398.889 35 e. H0: all μi are equal (i = 1, 2, 3), Ha: not all μi are equal. F * = 158.361/2.490 = 63.599, F (.99; 2, 33) = 5.31.

If F * ≤ 5.31 conclude H0, otherwise Ha. ConcludeHa. f. P -value = 0+ 16.11. b. Y1j = Y1. = .0735, Y2j = Y2. = .1905, Y3j = Y3. = .4600, Y4j = Y4. = .3655, Y5j = Y5. = .1250, Y6j = Y6. = .1515 c. eij: ... Source SS df MSBetween machines 2.28935 5 .45787Error 3.53060 114 .03097Total 5.81995 119 e. H0: all μi are equal (i = 1, ..., 6), Ha: not all μi are equal. F * = .45787/.03097 =14.78, F (.95; 5, 114) = 2.29.

If F * ≤ 2.29 conclude H0, otherwise Ha. ConcludeHa. f. P -value = 0+ 16.12. b. Y1j = Y1. = 24.55, Y2j = Y2. = 22.55, Y3j = Y3. = 11.75, Y4j = Y4.

= 14.80, Y5j = Y5. = 30.10 c.

eij: ... Source SS df MSBetween agents 4, 430.10 4 1, 107.525Error 714.65 95 7.523Total 5, 144.75 99 16-4 e. H0: all μi are equal (i = 1, ..., 5), Ha: not all μi are equal. F * = 1, 107.525/7.523 =147.22, F (.90; 4, 95) = 2.00. If F * ≤ 2.00 conclude H0, otherwise Ha. ConcludeHa. f. P -value = 0+ 16.15. μ = 80, τ1 = −15, τ2 = 0, τ3 = 15 16.16. μ. = 7.2, τ1 = −2.1, τ2 = −.9, τ3 = .7, τ4 = 2.3 16.17. a. μ. = 20.4725 b. H0: all τi equal zero (i = 1, ..., 5), Ha: not all τi equal zero. No 16.18. a. Y = 7.68.26.85.86.96.66.37.76.06.78.19.48.67.87.78.97.98.38.77.18.48.59.7 10.17.89.69.5X = ... b. ... defined in (16.63) d. Source SS df MSRegression 20.125 2 10.0625Error 15.362 24 .6401Total 35.487 26 e. H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F * = 10.0625/.6401 = 15.720,F (.95; 2, 24) = 3.40. If F * ≤ 3.40 conclude H0, otherwise Ha. Conclude Ha. 16.19. a. 16-6 Y = ...

− τ2 μ.

− τ1 τ2 μ. − τ1 − τ2 μ. − τ1 − τ2 μ. − τ1 − τ2 μ ... Y = 29.0 + .4X1 + .6X2, μ.

defined in (16.63) d. Source SS df MSRegression 7.60 2 3.80Error 116.40 12 9.70Total 124.00 14 e. H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F * = 3.80/9.70 = .392, F (.90; 2, 12) = 2.81. If F * ≤ 2.81 conclude H0, otherwiseHa. Conclude H0. 16.20. a. 16-7 Y = 29.. .4230 ..3326 ..22.X = 1 1 0... ... 1 0 11 0 ... 1 −86−10 6 β = μ. τ1 τ2 b. Xβ = μ. + τ1 ..μ. + τ1 μ. + τ2..μ. + τ2 μ. − 86τ1 − 10 6τ2 = μ1. μ2. ... μ2 μ3.. ..μ3 c. Y = 32.0 + 6.0X1 + 0.0X2, μ. defined in (16.80a) d.

Source SS df MSRegression 672 2 336.00Error 416 21 19.81Total 1088 23 e. H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F * = 336.00/19.81 = 16.96, F (.99; 2, 21) = 5.78. If F * ≤ 5.78 conclude H0,otherwise Ha. Conclude Ha. 16.21.

a. Y = 23.55556− 2.05556X1 + 4.19444X2, μ. defined in (16.63) b. Source SS df MSRegression 316.722 2 158.361Error 82.167 33 2.490Total 398.889 35 H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero.

F * = 158.361/2.490 = 63.599,F (.99; 2, 33) = 5.31. If F * ≤ 5.31 conclude H0, otherwise Ha. Conclude Ha. 16.22. a. Y = 38X1 + 32X2 + 24X3 b. Y = 32 16-8 c. H0: all μi are equal (i = 1, 2, 3), Ha: not all μi are equal. SSE(F) = 416, SSE(R) = 1, 088, F * = (672/2) ÷ (416/21) = 16.96, F (.99; 2, 21) = 5.78. If F * ≤ 5.78 conclude H0, otherwise Ha. Conclude Ha. 16.23. ... Δ/σ = .75 16.24. ... 16.25. a. ... 16.26. a. ... 16.27. ... 16.28. ... 16.29. ... 16-9 16.30. a. Yij = ... b. ... 16.31. ... In order to show ... derivatives equal to zero, simplifying, and substituting thenmaximum likelihood estimators ... Therefore to show (t*)2 = F*, it suffices to show:n1n2 nT (Y1. − Y2.)2 = n1(Y1. − Y..) 2 + n2(Y2. − Y..)2 Now, the right-hand side equals: ...

− Y1.)]2 =n1n2 nT (Y1. − Y2.)2 16-10 16.38.∑ witi = ∑ wi(μi − μ.) = ∑ wiμi − μ.∑ wi = μ. − μ. = 0 since∑ wi = 1 and μ.

= ∑ wiμi 16.39. a. Using (6.25) and substituting p for b: ... SSE = ... 16-11 Smallest P -value = .067 16.41.∑ (μi − μ.)2 = ... Setting this derivative equal to zero and solving yields p2 = .5. 16.42. H0: all μi are equal (i = 1, ..., 4), Ha: not all μi are equal. Source SS df MSBetween regions 13.9969 3 4.6656Error 187.3829 109 1.7191Total 201.3798 112 F * = 4.6656/1.7191 = 2.714, F (.95; 3, 109) = 2.688. If F * ≤ 2.688 conclude H0,otherwise Ha. Conclude Ha. 16.43.

H0: all μi are equal (i = 1, ..., 4), Ha: not all μi are equal. 16-11 Source SS df MSBetween regions 3.06777 3 1.02257Error 198.3121 109 1.81939Total 201.3798 112 F * = 1.02257/1.81938 = .562, F (.90; 3, 109) = 2.135.

If F * ≤ 2.135 conclude H0,otherwise Ha. Conclude Ha. 16.44. H0: all μi are equal (i = 1, ..., 4), Ha: not all μi are equal. Source SS df MSBetween regions .059181 3 .019727Error .268666 436 .000616Total .327847 439 F * = .019727/.000616 = 32.01, F (.95; 3, 436) = 2.6254. If F * ≤ 2.6254 conclude H0, otherwise Ha. Conclude Ha. 16.45. H0: all μi are equal (i = 1, ..., 4), Ha: not all μi are equal. Source SS df MSBetween regions 1.6613 3 .5538Error .7850 32 .0245Total 2.4463 35 F * = .5538/.0245 = 22.57, F (.95; 3, 32) = 2.9011. If F * ≤ 2.9011 conclude H0,otherwise Ha. Conclude Ha. 16.46. c. E{F*} =ν2 ν2 − 2= 1.2 d.

Expected proportion is .95. E{F*} = 117.9; E{MSTR} = 14, 144, E{MSE} = 144 f. φ = 8.05, expected proportion is 1 − β > .99. 16.47. a. 2.0, b. F* : .29 .59 .97 1.06 1.64 2.74P (F*) : 4/20 4/20 2/20 4/20 2/20 P -value = .10 c. P (F (1, 4) ≥ 2.74) = .17 16.48.

a.

F* : 0 .1 .4 .98 2.0 3.85 7.71 19.60P (F*) : 8/70 18/70 12/70 14/70 8/70 6/70 2/70 2/70 H0: μ1 = μ2, Ha: μ1 6= μ2.

F* = 7.71. P -value = P (F* ≥ 7.71) =.0571.

P -value = .10 conclude H0, otherwise Ha. Conclude Ha. b&c. F (.90; 1, 6) = 3.78 F (.95; 1, 6) = 5.99 F (.99; 1, 6) = 13.710/70 = .143 4/70 = .0571 2/70 = .0286 16-12 Chapter 17 ANALYSIS OF FACTOR LEVELMEANS 17.3. a. (i) and (iii) are contrasts. b. (i) L = Y1.

+ 3Y2. − 4Y3. s2{L} = 26MSE n (ii) L = .3Y1. + .5Y2. + .1Y3. + .1Y4., s2{L} = .36MSE n (iii) L =(Y1.

+ Y2 + Y3.)3 − Y4., s2{L} = 4MSE 3n 17.4. a. q(.90; 5, 54) = 3.765, F (.90; 5, 54) = 1.96 q 17.5 B2 2.66 3.13 t(.975; 54) = 2.005 2.66 3.13 t(.99; 54) = 2.40 15 2.66 3.13 t(.99667; 54) = 2.82 b. Refer to part (a) for S and B multiples. 17.5. a. q(.95; 5, 20) = 4.23, F (.95; 4, 20) = 2.87 g T S B2 2.99 3.39 t(.9875; 20) = 2.425 2.99 3.39 t(.995; 20) = 2.845 10 2.99 3.39 t(.9975; 20) = 3.15 b. q(.95; 5, 95) = 3.94, F (.95; 4, 95) = 2.46 g T S B2 2.79 3.14 t(.9875; 95) = 2.285 2.79 3.14 t(.995; 95) = 2.63 10 2.79 3.14 t(.9975; 95) = 2.87 17.7. a. d(.99; 2, 18) = 4.07, F (.99; 1, 18) = 8.29, T = 5.50, s{D} = 1.81 f. D = .92. ...

Y1. = 6.878, Y2. = 8.133, Y3. = 9.200 b. s{Y1.} = .3327, t(.95; 24) = 1.711, 6.878 ± 1.711(.3327), 6.309 ≤ μ1 ≤ 7.447 ...

[illegible]

Yij = μi + εij ... 17.21. ... Bonferroni ... 17.33. ... 17.37. ... 17.38. b. Expected proportion is .95. 17-11 17-12 Chapter 18 ANOVA DIAGNOSTICS ANDREMEDIAL MEASURES 18.4. a. See Problem 16.7c. b. r = .992 c. tij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 61 .9557 1.8377 −.1010 −1.4623 .0288 −.36152 −1.9821 −.0426 1.7197 .6011 −.4277 −.55753 −.9568 .6768 1.2464 −2.0391 .5395 .4035 i j = 7 j = 8 j = 9 j = 10 j = 11 j = 121 −.7592 1.0945 −1.17282 1.0009 −.2988 .2132 .7326 −1.3737 .3417 H0: no outliers, Ha: at least one outlier.

t(.999815; 23) = 4.17. If | tij |≤ 4.17 conclude H0, otherwise Ha. Conclude H0. 18.5. a. See Problem 16.8c. b.

r = .991 d. tij: i j = 1 j = 2 j = 3 j = 4 j = 51 −.4863 −1.2486 .5576 −.8516 2.36342 1.6992 −.2066 −1.7985 .4863 −.20663 1.0849 −1.0849 −.3456 .3456 .0000 H0: no outliers, Ha: at least one outlier. t(.99917; 11) = 4.13. If |tij| ≤ 4.13 conclude H0, otherwise Ha. Conclude H0. 18.6. a. See Problem 16.9c. b. r = .990 d. tij: 18-1 i j = 1 j = 2 j = 3 j = 4 j = 5 j = 61 −2.3926 .9589 .0000 .4714 1.2145 .47142 −.4647 .7019 1.7354 −.9449 −.2314 −.23143 .4832 2.1280 −.7301 −.9837 −.2405 −.4832 i j = 7 j = 8 j = 9 j = 101 −2.0656 .95892 −.7019 .7019 −.7019 .2314 H0: no outliers, Ha: at least one outlier. t(.99979; 20) = 4.22. If |tij| ≤ 4.22 conclude H0, otherwise Ha. Conclude H0. 18.7. a. See Problem 16.10c. b. r = .984 d. tij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 61 .9927 2.4931 −.3265 .3265 −.3265 .32652 .1630 −.4907 −.4907 .8234 −1.1646 .82343 1.0497 −.9360 2.5645 −.2719 .3811 1.0497 i j = 7 j = 8 j = 9 j = 10 j = 11 j = 121 −.9927 .9927 −1.7017 .3265 −1.7017 −.32652 −.4907 1.5185 .1630 −.4907 −1.1646 .82343 −.2719 −.9360 −1.6401 −.9360 .3811 −.2719 H0: no outliers, Ha: at least one outlier. t(.99965; 32) = 3.75. If |tij| ≤ 3.75 conclude H0, otherwise Ha. Conclude H0. 18.8. a. See Problem 16.11c. b. r = .992 d. tij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 6 j = 71 −.2477 .7360 −.0203 .6192 1.8045 .1538 −.66012 1.5815 −.4677 −.4095 1.6415 .2874 −.7594 −1.82873 −1.4648 1.8864 −.8150 −.0580 −1.4052 −.6396 .46484 .7243 1.2537 .9000 −.4386 −.5551 1.0764 .20035 −1.8560 .8443 −.3775 −.0871 .6105 .1451 −.66886 −.5901 −1.1767 .7477 1.8773 −.1829 .6893 −.4153 i j = 8 j = 9 j = 10 j = 11 j = 12 j = 13 j = 141 −2.0298 1.1472 −1.6656 1.8651 −.8355 −.5434 1.20632 .8121 −.7594 −1.2892 −.8179 2.0053 1.3427 .57843 −1.2863 .0580 .9323 .0580 .5230 .7565 1.46484 −1.3189 .6659 −.1480 −2.1035 −.2061 −1.0823 −1.37845 .5522 .9616 .0871 .4357 1.0204 −1.3754 .84436 .1074 1.6355 −1.2952 .2816 −.8238 −.2990 .0493 18-2 i j = 15 j = 16 j = 17 j = 18 j = 19 j = 201 .0958 .3281 1.0882 −.0203 −.4852 −1.54552 .9881 −.8765 −.1190 −.9940 −.4677 −.40953 −.0580 .1161 −.1161 .2322 −1.5246 .87364 .6659 1.0175 .8414 .3165 .4910 −.96465 −1.9168 .6688 .4357 .0871 1.3160 −1.79546 −1.2359 −.1248 1.6355 1.1590 −1.4141 −.5901 H0 : no outliers, Ha : at least one outlier. t(.9999417; 113) = 4.08. If |tij| ≤ 4.08 conclude H0, otherwise Ha. Conclude H0. 18.9. a. See Problem 16.12c. b.

r = .995 d. tij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 6 j = 71 −.2047 −.2047 1.6805 −1.7195 −1.3334 .1675 1.29512 −1.7195 −.9534 −.9534 .5404 −.2047 2.4771 .16753 −.6526 −.2792 −1.4100 .0930 .0930 −.6526 .84044 .0744 −.6714 1.1998 .4470 −1.0479 1.5835 −1.81725 1.0858 −3.1711 −.7840 1.8564 −.4097 −.7840 −.0372 i j = 8 j = 9 j = 10 j = 11 j = 12 j = 13 j = 141 .9157 −.5778 −1.3334 −.2047 .5404 −.5778 −.20472 .5404 2.0738 −1.3334 .5404 .9157 −.5778 −.95343 −1.0290 −1.4100 −.2792 1.6029 .0930 2.3955 .84044 1.1998 −1.4293 .8216 .0744 −1.0479 −.6714 −.67145 .3351 −.4097 −.7840 1.0858 −.0372 .7089 1.0858 i j = 15 j = 16 j = 17 j = 18 j = 19 j = 201 2.1951 −.5778 −.5778 .9157 .5404 .16752 .5404 −.2047 −1.3334 1.2951 −.2047 −.57783 .4657 −.2792 .8404 −1.0290 −.2792 .93044 −.2978 .8216 .4470 .8216 −.2978 .44705 −.4097 1.8564 .7089 −1.5448 −.0372 −.4097 H0 : no outliers, Ha : at least one outlier. t(.999875; 94) = 3.81. If |tij| ≤ 3.81 conclude H0, otherwise Ha. Conclude H0. 18.11. H0: all σ2i are equal (i = 1, 2, 3), Ha: not all σ2 i are equal. Y1 = 6.80, Y2 = 8.20, Y3 = 9.55, MSTR = .0064815, MSE = .26465, F *BF = .0064815/.26465 = .02, F (.95; 2, 24) = 3.40. If F * BF ≤ 3.40 conclude H0,otherwise Ha. Conclude H0. P -value = .98 18.12. H0: all σ2i are equal (i = 1, 2, 3), Ha: not all σ2 i are equal. Y1 = 40.0, Y2 = 31.0, Y3 = 22.5, MSTR = 2.96667, MSE = 11.30476, F *BF = 2.96667/11.30476 = .26, F (.90; 2, 21) = 2.575. If F * BF ≤ 2.575 concludeH0, otherwise Ha. Conclude H0.

P -value = .77 18-3 18.13.

a. H0: all σ2i are equal (i = 1, 2, 3), Ha: not all σ2 i are equal. s1 = 1.7321, s2 = 1.2881, s3 = 1.6765, ni ≡ 12, H∗ = (1.7321)2/(1.2881)2 = 1.808, H(.99; 3, 11) = 6.75.

If H∗ ≤ 6.75 conclude H0, otherwise Ha. Conclude H0.P -value > .05 b. Y1 = 21.5, Y2 = 27.5, Y3 = 21.0, MSTR = .19444, MSE = .93434, F *BF = .19444/.93434 = .21, F (.99; 2, 33) = 5.31. If F * BF ≤ 5.31 conclude H0,otherwise Ha. Conclude H0. P -value = .81 18.14. a.

H0: all σ2i are equal (i = 1, ..., 6), Ha: not all σ2 i are equal. s1 = .1925, s2 = .1854, s3 = .1646, s4 = .1654, s5 = .1727, s6 = .1735, ni ≡ 20,H∗ = (.1925)2/(.1646)2 = 1.3677, H(.99; 6, 19) = 5.2. If H∗ ≤ 5.2 conclude H0,otherwise Ha. Conclude H0. P -value > .05 b. Y1 = .08, Y2 = .12, Y3 = .47, Y4 = .41, Y5 = .175, Y6 = .125, MSTR = .002336,MSE = .012336, F * BF = .002336/.012336 = .19, F (.99; 5, 114) = 3.18. If F *BF ≤ 3.18 conclude H0, otherwise Ha. Conclude H0. P -value = .97 18.15. a. Y1. = 3.90, Y2. = 1.15, Y3. = 2.00, Y4. = 3.40 eij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 6 j = 71 .10 −.90 1.10 .10 2.10 −.90 −1.902 −1.15 .85 −1.15 1.85 .85 −.15 −1.153 0.0 −1.00 −2.00 1.00 2.00 −1.00 1.004 1.60 −1.40 .60 .60 2.60 1.60 −.40 i j = 8 j = 9 j = 10 j = 11 j = 12 j = 13 j = 141 1.10 3.10 −2.90 −1.90 1.10 .10 3.102 1.85 −.15 −1.15 −1.15 −.15 −.15 −1.153 2.00 0.0 −2.00 −1.00 1.00 0.0 2.004 1.60 3.60 −.40 −2.40 −3.40 −1.40 −.40 i j = 15 j = 16 j = 17 j = 18 j = 19 j = 201 .10 1.10 −3.90 .10 −2.90 2.102 −.15 1.85 −.15 .85 .85 −1.153 −2.00 −1.00 1.00 −2.00 0.0 2.004 −.40 .60 −2.40 1.60 −1.40 −.40 c. H0: all σ2i are equal (i = 1, 2, 3, 4), Ha: not all σ2 i are equal. Y1 = 4, Y2 = 1, Y3 = 2, Y4 = 3, MSTR = 1.64583, MSE = .96776, F *BF = 1.64583/.96776 = 1.70, F (.90; 3, 76) = 2.157. If F * BF ≤ 2.157 conclude H0,otherwise Ha. Conclude H0.

P -value = .17 d. i Yi. si 1 3.9000 1.97082 1.1500 1.08943 2.0000 1.45104 3.4000 1.7889 18-4 e. λ SSE−1.0 434.22−.8 355.23−.6 297.21−.4 254.90−.2 224.59−.1 213.09 0 203.67 λ SSE.1 196.14.2 190.35.4 183.48.6 182.41.8 186.91 1.0 197.15 Yes 18.16.

a.

Y′1. = 1.8714, Y′2. = .8427, Y′3. = 1.2293, Y′4 . = 1.7471 e′ij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 6 j = 71 .129 −.139 .365 .129 .578 −.139 −.4572 −.843 .572 −.843 .889 .572 .157 −.8433 .185 −.229 −1.229 .503 .771 −.229 .5034 .489 −.333 .253 .253 .702 .489 −.015 i j = 8 j = 9 j = 10 j = 11 j = 12 j = 13 j = 141 .365 .774 −.871 −.457 .365 .129 .7742 .889 .157 −.843 −.843 .157 .157 −.8433 .771 .185 −1.229 −.229 .503 .185 .7714 .489 .899 −.015 −.747 −1.747 −.333 −.015 i j = 15 j = 16 j = 17 j = 18 j = 19 j = 201 .129 .365 −1.871 .129 −.871 .5782 .157 .889 .157 .572 .572 −.8433 −1.229 −.229 .503 −1.229 .185 .7714 −.015 .253 −.747 .489 −.333 −.015 b.

r = .964 c. H0: all σ2i are equal (i = 1, 2, 3, 4), Ha: not all σ2 i are equal. Y1 = 2.000, Y2 = 1.000, Y3 = 1.414, Y4 = 1.732, MSTR = .07895, MSE = .20441,F * BF = .07895/.20441 = .39, F (.90; 3, 76) = 2.157. If F *BF ≤ 2.157 conclude H0, otherwise Ha. Conclude H0. 18.17. a. Y1. = 3.5625, Y2. = 5.8750, Y3. = 10.6875, Y4. = 15.5625 eij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 61 .4375 −.5625 −1.5625 −.5625 .4375 .43752 1.1250 .1250 −1.8750 .1250 1.1250 −3.87503 1.3125 −4.6875 3.3125 1.3125 −.6875 −1.68754 .4375 −1.5625 −9.5625 3.4375 −3.5625 −5.5625 18-5 i j = 7 j = 8 j = 9 j = 10 j = 11 j = 121 −.5625 2.4375 1.4375 .4375 −1.5625 .43752 3.1250 −.8750 −.8750 3.1250 −2.8750 2.12503 1.3125 6.3125 −3.6875 −4.6875 1.3125 .31254 −.5625 8.4375 −5.5625 7.4375 1.4375 4.4375 i j = 13 j = 14 j = 15 j = 161 .4375 −1.5625 −.5625 .43752 .1250 −1.8750 1.1250 .12503 −4.6875 2.3125 −.6875 3.31254 −.5625 2.4375 −7.5625 6.4375 c. H0: all σ2i are equal (i = 1, 2, 3, 4), Ha: not all σ2 i are equal. Y1 = 4.0, Y2 = 6.0, Y3 = 11.5, Y4 = 16.5, MSTR = 37.1823, MSE = 3.8969,F * BF = 37.1823/3.8969 = 9.54, F (.95; 3, 60) = 2.76.

If F *BF ≤ 2.76 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ d. i Yi. si 1 3.5625 1.09352 5.8750 1.99583 10.6875 3.23974 16.5625 5.3786 e. λ SSE−1.0 1, 038.26−.8 790.43−.6 624.41−.4 516.16−.2 450.16−.1 429.84 0 416.84 λ SSE.1 410.65.2 410.92.4 430.49.6 476.68.8 553.64 1.0 669.06 Yes 18.18. a. Y′1. = .5314, Y′2. = .7400, Y′3. = 1.0080, Y′4. = 1.1943 e′ij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 6 j = 71 .071 −.054 −.230 −.054 .071 .071 −.054 .2472 .105 .038 −.138 .038 .105 −.439 .214 −.0413 .071 −.230 .138 .071 −.008 −.054 .071 .2224 .036 −.018 −.349 .107 −.080 −.153 .010 .204 i j = 9 j = 10 j = 11 j = 12 j = 13 j = 14 j = 15 j = 161 .168 .071 −.230 .071 .071 −.230 −.054 .0712 −.041 .214 −.263 .163 .038 −.138 .105 .0383 −.163 −.230 .071 .033 −.230 .106 −.008 .1384 −.153 .186 .061 .128 .010 .085 −.240 .167 18-6 b. r = .971 c.

H0: all σ2i are equal (i = 1, 2, 3, 4), Ha: not all σ2 i are equal.

Y1 = .6021, Y2 = .7782, Y3 = 1.0603, Y4 = 1.2173, MSTR = .001214, MSE = .01241, F *BF = .001214/.01241 = .10, F (.95; 3, 60) = 2.76. If F *BF ≤ 2.76 conclude H0, otherwise Ha. Conclude H0. 18.19. i: 1 2 3 4si: 1.97084 1.08942 1.45095 1.78885wi: .25745 .84257 .47500 .31250 H0: all μi are equal (i = 1, 2, 3, 4), Ha: not all μi are equal. SSEw(F) = 76, dfF = 76, SSEw(R) = 118.54385, dfR = 79, F *w = [(118.54385− 76)/3]÷ (76/76) = 14.18, F (.95; 3, 76) = 2.725. If F *w ≤ 2.725 conclude H0, otherwise Ha. Conclude Ha. 18.20. i: 1 2 3 4si: 1.09354 1.99583 3.23973 5.37858wi: .83624 .25105 .09528 .034567 H0: all μi are equal (i = 1, 2, 3, 4), Ha: not all μi are equal. SSEw(F) = 60, dfF = 60, SSEw(R) = 213.9541, dfR = 63, F *w = [(213.9541− 60)/3]÷ (60/60) = 51.32, F (.99; 3, 60) = 4.13. If F *w ≤ 4.13 conclude H0, otherwise Ha. Conclude Ha. 18.23. a. H0: all μi are equal (i = 1, 2, 3, 4), Ha: not all μi are equal. MSTR = 470.8125, MSE = 28.9740, F *R = 470.8125/28.9740 = 16.25, F (.95; 2, 24) = 3.40. If F *R ≤ 3.40 conclude H0, otherwise Ha. Conclude Ha. b. P -value = 0+ e. R1. = 6.50, R2.

= 15.50, R3. = 22.25, B = z(.9833) = 2.13 Comparison Testing Limits1 and 2 −9.00± 2.13(3.500) −16.455 and −1.5451 and 3 15.75± 2.13(4.183) −24.660 and −9.8402 and 3 −6.75± 2.13(3.969) −15.204 and 1.704 Group 1Low Level i = 1 Group 2Moderate level i = 2 High level i = 3 18.24.

a. H0: all μi are equal (i = 1, 2, 3), Ha: not all μi are equal. MSTR = 1, 297.0000, MSE = 37.6667, F *R = 1, 297.0000/37.6667 = 34.43, F (.99; 2, 33) = 5.31. If F *R ≤ 5.31 conclude H0, otherwise Ha. Conclude Ha. 18-7 b. P -value = 0+ e. R1. = 12.792, R2. = 30.500, R3. = 12.208, B = z(.9833) = 2.128 Comparison Testing Limits1 and 2 −17.708± 2.128(4.301) −26.861 and −8.5551 and 3 .584± 2.128(4.301) −8.569 and 9.7372 and 3 18.292± 2.128(4.301) 9.140 and 27.445 Group 1Young i = 1Elderly i = 3 Group 2Middle i = 2 18.25. b. H0: all μi are equal (i = 1, 2, 3), Ha: not all μi are equal. MSTR = 465.6000, MSE = 48.7519, F *R = 465.6000/48.7519 = 9.550, F (.95; 2, 27) = 3.354. If F *R ≤ 3.354 conclude H0, otherwise Ha. Conclude Ha. P -value = .0007 c. R1. = 21.1, R2. = 7.9, R3. = 17.5, B = z(.99167) = 2.394 Comparison Testing Limits1 and 2 13.2± 2.394(3.937) 3.775 and 22.6251 and 3 3.6± 2.394(3.937) −5.825 and 13.0252 and 3 −9.6± 2.394(3.937) −19.025 and −.175 Group 1Production i = 2 Group 2Sales i = 1 Research i = 3 18.26. Yij = μi + βtj + εij, tj = 1, ..., 7 18.27.nT∑ i=1 i =nT (nT + 1) 2 nT∑ i=1 i2 =nT (nT + 1)(2nT + 1) 6 SSTO =nT∑ i=1 i2 −(nT∑ i=1 i)2 /nT =nT (nT + 1)(2nT + 1) 6− n2 T (nT + 1)2 4nT =nT (nT + 1)(nT − 1) 12 SSTO/(nT − 1) = nT (nT + 1)/12 18.28. X2KW = SSTR÷ SSTO nT − 1 F *R = SSTR r − 1÷ SSTO − SSTR nT − r = (X2 KW r − 1) (SSTO nT − 1)÷ [SSTO −X2 KW (SSTO nT − 1)] nT − r =[(nT − r)X2 KW] SSTO (r − 1)(nT − 1)÷ SSTO(nT − 1−X2 KW) nT − 1 18-8 = [(nT − r)X2KW]÷ [(r − 1)(nT − 1−X2 KW)] 18.29. b. r = .994 c. H0: all σ2i are equal (i = 1, ..., 4), Ha: not all σ2 i are equal. Y1 = 4.85, Y2 = 4.40, Y3 = 4.20, Y4 = 4.45, MSTR = .97716, MSE = .70526, F *BF = .97716/.70526 = 1.39, F (.95; 3, 109) = 2.688. If F * BF ≤ 2.688 conclude H0,otherwise Ha. Conclude H0. P -value = .25 18.30. b.

i Yi. si 1 11.08893 2.669622 9.68344 1.192943 9.19135 1.224994 8.11375 1.00312 c. λ SSE−1.0 206.15−.8 208.55−.6 212.09−.4 216.87−.2 223.09−.1 226.79 0 230.93 λ SSE.1 235.54.2 240.65.4 252.56.6 267.04.8 284.55 1.0 305.66 Yes e. r = .995 f. H0: all σ2i are equal (i = 1, ..., 4), Ha: not all σ2 i are equal. Y1 = .09332, Y2 = .10199, Y3 = .11111, Y4 = .12799, MSTR = .00008213, MSE = .00008472, F *BF = .00008213/.00008472 = .97, F (.99; 3, 109) = 3.97. If F *BF ≤ 3.97 conclude H0, otherwise Ha. Conclude H0. P -value = .41 g.

Source SS df MSBetween regions .0103495 3 .0034498Error .0254284 109 .0002333Total .0357779 112 H0: all μi are equal (i = 1, ..., 4), Ha: not all μi are equal. F * = .0034498/.0002333 = 14.787, F (.99; 3, 109) = 3.967.

If F * ≤ 3.967 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ 18.31. b. r = .9154 c. H0: all σ2i are equal (i = 1, ..., 4), Ha: not all σ2 i are equal. 18-9 Y1 = .03489, Y2 = .04781, Y3 = .06948, Y4 = .05966, MSTR = .001001, MSE =.000326, F * BF = .001001/.000326 = 3.07, F (.99; 3, 436) = 3.83. If F *BF ≤ 3.83 conclude H0, otherwise Ha. Conclude H0. P -value = .028 18.32. b. r = .9902 c. H0: all σ2i are equal (i = 1, ..., 4), Ha: not all σ2 i are equal. Y1 = 2.415, Y2 = 2.705, Y3 = 2.480, Y4 = 2.880, MSTR = .0106, MSE = .0085,F * BF = .0106/.0085 = 1.25, F (.95; 3, 32) = 2.90. If F *BF ≤ 2.90 conclude H0, otherwise Ha. Conclude H0. P -value = .31 18.33. a. H0: all μi are equal (i = 1, ..., 4), Ha: not all μi are equal. MSTR = 2, 582.575, MSE = 1, 031.966, F *R = 2, 582.575/1, 031.966 = 2.50, F (.95; 3, 109) = 2.69. If F *R ≤ 2.69 conclude H0, otherwise Ha. Conclude H0. P -value = .063 c. R1. = 69.196, R2. = 57.797, R3. = 47.189, R4. = 56.750, B = z(.99167) = 2.394 Comparison Testing Limits1 and 2 11.399± 2.394(8.479) −8.900 and 31.6981 and 3 22.007± 2.394(8.207) 2.359 and 41.6551 and 4 12.446± 2.394(10.268) −12.136 and 37.0282 and 3 10.608± 2.394(7.910) −8.329 and 29.5452 and 4 1.047± 2.394(10.032) −22.970 and 25.0643 and 4 −9.561± 2.394(9.803) −33.029 and 13.907 Group 1Region 3Region 4Region 2 Group 2Region 4Region 2Region 1 18.34. a. H0: all μi are equal (i = 1, ..., 4), Ha: not all μi are equal. MSTR = 651, 049, MSE = 11, 802, F *R = 651, 049/11, 802 = 55.17, F (.95; 3, 436) = 2.6254. If F *R ≤ 2.6254 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ c. R1. = 120.4, R2. = 192.9, R3.

= 290.7, R4. = 254.6, n1 = 103, n2 = 108, n3 = 152, n4 = 77, B = z(.99583) = 2.638 Comparison Testing Limits1 and 2 −72.5± 2.638(17.51) −118.7 and −26.31 and 3 −170.3± 2.638(16.23) −213.1 and −127.51 and 4 −134.2± 2.638(19.16) −184.7 and −83.72 and 3 −97.8± 2.638(16.00) −140.0 and −55.62 and 4 −61.7± 2.638(18.97) −111.7 and −11.73 and 4 36.1± 2.638(17.79) −10.8 and 83.0 Group 1Region 1 Group 2Region 2 Group 3Region 3Region 4 18-10 18.35. a. H0: all μi are equal (i = 1, ..., 4), Ha: not all μi are equal. MSTR = 955.5, MSE = 31.8, F *R = 955.5/31.8 = 30.1, F (.95; 3, 32) = 2.90. If F *R ≤ 2.90 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ c. R1. = 7.938, R2. = 22.375, R3.

= 8.571, R4. = 27.962, n1 = 8, n2 = 8, n3 = 7, n4 = 13, B = z(.99583) = 2.638 Comparison Testing Limits1 and 2 −14.437± 2.638(5.268) −28.334 and −.5411 and 3 −.633± 2.638(5.453) −15.017 and 13.7511 and 4 −20.024± 2.638(4.734) −32.513 and −7.5352 and 3 13.804± 2.638(5.453) −.580 and 28.1882 and 4 −5.587± 2.638(4.734) −18.076 and 6.9023 and 4 −19.391± 2.638(4.939) −32.421 and −6.361 Group 1Region 1Region 3 Group 2Region 2Region 3 Group 3Region 2Region 4 18.36.

Under H0, each arrangement of the ranks 1, ..., 4 into groups of size 2 are equally likely and occur with probability 2!2!/4! = 1/6. The values of F *R computed for the six arrangements are 0, .5, and 8, each occurring twice. Therefore the probabilityfunction f(x) is: x f(x) = P (F *R = x) 0 1/3.5 1/38 1/3 18.37. c. For the F distribution with ν1 = 2 degrees of freedom and ν2 = 27 degrees offreedom, the mean is: ν2 ν2 − 2= 1.08 and the standard deviation is: ν2 ν2 − 2 [2(ν1 + ν2 − 2) ν1(ν2 − 4)]1/2 = 1.17.

d. Expect 90% less than 2.51 and 99% less than 5.49. 18-11 18-12 Chapter 19 TWO-FACTOR ANALYSIS OFVARIANCE WITH EQUALSAMPLE SIZES 19.1. a. 8 b. Infection risk 19.3. (αβ)11 = μ11 − (μ.. + α1 + β1) = 9− (12 + 1− 3) = −1 (αβ)12 = μ12 − (μ.. + α1 + β2) = 12− (12 + 1− 1) = 0 (αβ)13 = μ13 − (μ.. + α1 + β3) = 18− (12 + 1 + 4) = 1 (αβ)21 = μ21 − (μ.. + α2 + β1) = 9− (12− 1− 3) = 1 (αβ)22 = μ22 − (μ.. + α2 + β2) = 10− (12− 1− 1) = 0 (αβ)23 = μ23 − (μ.. + α2 + β3) = 14− (12− 1 + 4) = −1 19.4. a. μ1. = 31, μ2. = 37 b. α1 = μ1. − μ.. = 31− 34 = −3, α2 = μ2. − μ.. = 37− 34 = 3 19.5. a. μ.j = 269 (j = 1, ..., 4), βj = μ.j − μ.., βj = 0 (j = 1, ..., 4) c. loge μij: Factor BFactor A B1 B2 B3 B4 A1 5.5215 5.5797 5.5910 5.5947A2 5.6630 5.6095 5.5984 5.5947 19.7. a. E{MSE} = 1.96, E{MSA} = 541.96 19.8. a. E{MSE} = 16, E{MSAB} = 952 19.10. a. Y11. = 21.66667, Y12. = 21.33333, Y21. = 27.83333, Y22. = 27.66667, Y31. = 22.33333, Y32. = 20.50000 b. eijk: 19-1 i j = 1 j = 21 −.66667 −.33333 1.33333 .66667−2.66667 −1.33333 .33333 −.33333 .33333 −2.333331.33333 3.66667 i j = 1 j = 22 2.16667 −1.66667 1.16667 1.33333−1.83333 −.66667 .16667 .33333−.83333 −.66667−.83333 1.33333 i j = 1 j = 23 2.66667 2.50000 −.33333 −1.50000.66667 −.50000 −1.33333 .50000−.33333 −.50000−1.33333 −.50000 d.

r = .986 19.11. b. Source SS df MSTreatments 327.222 5 65.444 A (age) 316.722 2 158.361B (gender) 5.444 1 5.444AB interactions 5.056 2 2.528 Error 71.667 30 2.389Total 398.889 35 Yes, factor A (age) accounts for most of the total variability.

c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F * = 2.528/2.389 = 1.06, F (.95; 2, 30) = 3.32. If F * ≤ 3.32 conclude H0, otherwise Ha. Conclude H0. P -value = .36 d. H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F * = 158.361/2.389 = 66.29, F (.95; 2, 30) = 3.32. If F * ≤ 3.32 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F * = 5.444/2.389 = 2.28, F (.95; 1, 30) = 4.17. If F * ≤ 4.17 conclude H0, otherwise Ha. Conclude H0. P -value = .14 e.

α ≤ .143 g. SSA = SSTR, SSB + SSAB + SSE = SSE, yes 19.12. a. Y11. = 9.2, Y12.

= 13.6, Y21. = 13.0, Y22.

= 16.4 b. eijk: i j = 1 j = 21 1.8 1.4 −2.2 −1.62.8 .4 −3.2 −2.6.8 2.4 i j = 1 j = 22 −1.0 −2.4 3.0 .6−3.0 −3.40 3.61.0 1.6 d. r = .976 19.13. b. 19-2 Source SS df MSTreatments 131.75 3 43.917 A (eye contact) 54.45 1 54.45B (gender) 76.05 1 76.05AB interactions 1.25 1 1.25 Error 97.20 16 6.075Total 228.95 19 c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F * = 1.25/6.075 = .21,F (.99; 1, 16) = 8.53. If F * ≤ 8.53 conclude H0, otherwise Ha. Conclude H0.P -value = .66 d. H0: α1 = α2 = 0, Ha: not both α1 and α2 equal zero. F * = 54.45/6.075 = 8.96,F (.99; 1, 16) = 8.53.

If F * ≤ 8.53 conclude H0, otherwise Ha. Conclude Ha.P -value = .009 H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F * = 76.05/6.075 = 12.52,F (.99; 1, 16) = 8.53. If F * ≤ 8.53 conclude H0, otherwise Ha. Conclude Ha.P -value = .003. e.

α ≤ .030 19.14. a. Y11. = 2.475, Y12. = 4.600, Y13.

= 4.575, Y21. = 5.450, Y22. = 8.925, Y23. = 9.125, Y31. = 5.975, Y32. = 10.275, Y33. = 13.250 b. eijk: i j = 1 j = 2 j = 31 −.075 0 .225 .225 −.400 −.075−.175 .300 −.175 .025 .100 .025 i j = 1 j = 2 j = 32 .350 −.025 −.025 −.250 .175 .175.050 −.225 −.425 −.150 .075 .275 i j = 1 j = 2 j = 33 .125 −.375 .250 −.275 .225 −.250−.075 .325 .050 .225 −.175 −.050 d. r = .988 19.15. b. Source SS df MSTreatments 373.105 8 46.638 A (ingredient 1) 220.020 2 110.010B (ingredient 2) 123.660 2 61.830AB interactions 29.425 4 7.356 Error 1.625 27 .0602Total 374.730 35 c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F * = 7.356/.0602 =122.19, F (.95; 4, 27) = 2.73. If F * ≤ 2.73 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ 19-3 d. H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F * = 110.010/.0602 = 1, 827.41, F (.95; 2, 27) = 3.35. If F * ≤ 3.35 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ H0: all βj equal zero (j = 1, 2, 3), Ha: not all βj equal zero. F * = 61.830/.0602 =1, 027.08, F (.95; 2, 27) = 3.35. If F * ≤ 3.35 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ e. α ≤ .143 19.16. a. Y11. = 59.8, Y12. = 47.8, Y13. = 58.4, Y21. = 48.4, Y22. = 61.2, Y23. = 56.2, Y31. = 60.2, Y32. = 60.8, Y33. = 49.6 b.

eijk: i j = 1 j = 2 j = 31 2.2 9.2 .6 −11.8 −2.8 −5.43.2 −8.8 8.6 −2.8 6.2 7.69.2 −3.8 −11.4 i j = 1 j = 2 j = 32 2.6 −.2 −1.2 8.6 −3.2 1.8−3.4 8.8 −6.2 1.6 4.8 12.8−9.4 −10.2 −7.2 i j = 1 j = 2 j = 33 −1.2 −2.8 −2.6 4.8 2.2 6.4−5.2 9.2 1.4−8.2 −7.8 −5.6 9.8 −.8 .4 d. r = .989 19.17.

b.

Source SS df MSTreatments 1, 268.17778 8 158.52222 A (technician) 24.57778 2 12.28889B (make) 28.31111 2 14.15556AB interactions 1, 215.28889 4 303.82222 Error 1, 872.40000 36 52.01111Total 3, 140.57778 44 c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F * = 303.82222/52.01111 =5.84, F (.99; 4, 36) = 3.89.

If F * ≤ 3.89 conclude H0, otherwise Ha. Conclude Ha.P -value = .001 d. H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero.

F * = 12.28889/52.01111 =.24, F (.99; 2, 36) = 5.25. If F * ≤ 5.25 conclude H0, otherwise Ha. Conclude H0.P -value = .79 H0: all βj equal zero (j = 1, 2, 3), Ha: not all βj equal zero. F * = 14.15556/52.01111 =.27, F (.99; 2, 36) = 5.25. If F * ≤ 5.25 conclude H0, otherwise Ha. Conclude H0.P -value = .76 e. α ≤ .003 19-4 19.18. a. Y′11. = .44348, Y′12.

= .80997, Y′13. = 1.10670, Y′21. = .39823, Y′22. = .58096, Y′23. = .86639 e′ijk: i j = 1 j = 2 j = 31 −.44348 .03364 −.33285 −.11100 .09742 .12375 .03364 −.44348 −.11100 −.20791 −.06531 −.20361−.14245 .33467 .09312 −.50894 −.15246 .38466 .15858 .40162 .30398 −.03182 −.32855 −.50464−.44348 .51076 .39415 .51225 .30827 .34046 i j = 1 j = 2 j = 32 −.39823 .07880 .19719 −.27993 .17500 .33773 −.09720 .50486 .02110 .02110 .08785 −.16742−.09720 .30074 −.10384 .26413 .24755 .13361−.39823 −.39823 −.58096 .32213 −.26433 −.02130 .30074 .20383 −.27993 .41904 .03670 −.56536 c. r = .987 19.19. b. Source SS df MSTreatments 3.76217 5 .75243 A (duration) .44129 1 .44129B (weight gain) 3.20098 2 1.60049AB interactions .11989 2 .05995 Error 5.46770 54 .10125Total 9.22987 59 c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero.

F * = .05995/.10125 = .59,F (.95; 2, 54) = 3.17. If F * ≤ 3.17 conclude H0, otherwise Ha. Conclude H0. P -value = .56 d. H0: α1 = α2 = 0, Ha: not both α1 and α2 equal zero. F * = .44129/.10125 = 4.36,F (.95; 1, 54) = 4.02. If F * ≤ 4.02 conclude H0, otherwise Ha. Conclude Ha.P -value = .04 H0: all βj equal zero (j = 1, 2, 3), Ha: not all βj equal zero. F * = 1.60049/.10125 =15.81, F (.95; 2, 54) = 3.17. If F * ≤ 3.17 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ e. α ≤ .143 19.20.

a. Y11. = 222.00, Y12. = 106.50, Y13.

= 60.50, Y21. = 62.25, Y22. = 44.75, Y23. = 38.75 b. eijk: i j = 1 j = 2 j = 31 18 3.5 −4.5 −16 11.5 −.5−5 −3.5 7.5 3 −11.5 −2.5 i j = 1 j = 2 j = 32 8.75 2.25 −1.75 −9.25 7.25 −5.755.75 −13.75 1.25 −5.25 4.25 6.25 19-5 d. r = .994 19.21. b. Source SS df MSTreatments 96, 024.37500 5 19, 204.87500 A (type) 39, 447.04167 1 39, 447.04167B (years) 36, 412.00000 2 18, 206.00000AB interactions 20, 165.33333 2 10, 082.66667 Error 1, 550.25000 18 86.12500Total 97, 574.62500 23 c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F * = 10, 082.66667/86.12500 =117.07, F (.99; 2, 18) = 6.01. If F * ≤ 6.01 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ d. H0: α1 = α2 = 0, Ha: not both α1 and α2 equal zero. F * = 39, 447.04167/86.12500 =458.02, F (.99; 1, 18) = 8.29. If F * ≤ 8.29 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ H0: all βj equal zero (j = 1, 2, 3), Ha: not all βj equal zero. F * = 18, 206.00000/86.12500 =211.39, F (.99; 2, 18) = 6.01. If F * ≤ 6.01 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ e. α ≤ .030 19.27. a.

B = t(.9975; 75) = 2.8925, q(.95; 5, 75) = 3.96, T = 2.800 b. B = t(.99167; 27) = 2.552, q(.95; 3, 27) = 3.51, T = 2.482 19.28. (1) B = t(.9972; 324) = 2.791, (2) F (.975; 5, 324) = 2.606, S = 3.6097 (3) F (.95; 10, 324) = 1.86, S = 4.3128 19.30. a. s{Y11.} = .631, t(.975; 30) = 2.042, 21.66667± 2.042(.631), 20.378 ≤ μ11 ≤ 22.955 b. Y.1. = 23.94, Y.2. = 23.17 c. D = .77, s{D} = .5152, t(.975; 30) = 2.042, .77±2.042(.5152), −.282 ≤ D ≤ 1.822 d. Y1.. = 21.50, Y2..

= 27.75, Y3.. = 21.42 e. D1 = Y1..−Y2.. = −6.25, D2 = Y1..−Y3.. = .08, D3 = Y2..−Y3.. = 6.33, s{Di} = .631(i = 1, 2, 3), q(.90; 3, 30) = 3.02, T = 2.1355 −6.25± 2.1355(.631) −7.598 ≤ D1 ≤ −4.902.08± 2.1355(.631) −1.268 ≤ D2 ≤ 1.428 6.33± 2.1355(.631) 4.982 ≤ D3 ≤ 7.678 f. Yes g.

L = −6.29, s{L} = .5465, t(.976; 30) = 2.042, −6.29 ± 2.042(.5465), −7.406 ≤L ≤ −5.174 h. L = .3μ12 + .6μ22 + .1μ32, L = 25.05000, s{L} = .4280, t(.975; 30) = 2.042,25.05000± 2.042(.4280), 24.176 ≤ L ≤ 25.924 19-6 19.31. a. s{Y21.} = 1.1023, t(.995; 16) = 2.921, 13.0± 2.921(1.1023), 9.780 ≤ μ21 ≤ 16.220 b. s{Y1..} = .7794, t(.995; 16) = 2.921, 11.4± 2.921(.7794), 9.123 ≤ μ1. ≤ 13.677 c. Y1.. = 11.1, Y2.. = 15.0 d. s{Y.1.} = s{Y.2.} = .7794, t(.995; 16) = 2.921 11.1± 2.921(.7794) 8.823 ≤ μ.1 ≤ 13.37715.0± 2.921(.7794) 12.723 ≤ μ.2 ≤ 17.277 98 percent e. Y1.. = 11.4, Y2.. = 14.7 f. D1 = 3.3, D2 = 3.9, s{Di} = 1.1023 (i = 1, 2), B = t(.9875; 16) = 2.473 3.3± 2.473(1.1023) .574 ≤ D1 ≤ 6.0263.9± 2.473(1.1023) 1.174 ≤ D2 ≤ 6.626 g. Yes 19.32. a. s{Y23.} = .1227, t(.975; 27) = 2.052, 9.125± 2.052(.1227), 8.873 ≤ μ23 ≤ 9.377 b. D = 2.125, s{D} = .1735, t(.975; 27) = 2.052, 2.125± 2.052(.1735), 1.769 ≤ D ≤2.481 c. L1 = 2.1125, L2 = 3.5750, L3 = 5.7875, L4 = 1.4625, L5 = 3.6750, L6 = 2.2125,s{Li} = .1502 (i = 1, 2, 3), s{Li} = .2125 (i = 4, 5, 6), F (.90; 8, 27) = 1.90,S = 3.899 2.1125± 3.899(.1502) 1.527 ≤ L1 ≤ 2.6983.5750± 3.899(.1502) 2.989 ≤ L2 ≤ 4.1615.7875± 3.899(.1502) 5.202 ≤ L3 ≤ 6.3731.4625± 3.899(.2125) .634 ≤ L4 ≤ 2.2913.6750± 3.899(.2125) 2.846 ≤ L5 ≤ 4.5042.2125± 3.899(.2125) 1.384 ≤ L6 ≤ 3.041 d. s{Di} = .1735, q(.90; 9, 27) = 4.31, T = 3.048, Ts{Di} = .529, Y33.

= 13.250 e. i j 1/Yij. √Yij. 1 1 .404 1.5731 2 .217 2.1451 3 .219 2.1392 1 .183 2.3352 2 .112 2.9872 3 .110 3.0213 1 .167 2.4443 2 .097 3.2053 3 .075 3.640 19.33. a. s{Y11.} = 3.2252, t(.995; 36) = 2.7195, 59.8± 2.7195(3.2252), 51.029 ≤ μ11 ≤ 68.571 b. D = 12.8, s{D} = 4.5612, t(.995; 36) = 2.7195, 12.8±2.7195(4.5612), .396 ≤ D ≤25.204 19-7 c.

D1 = Y11. − Y12. = 12.0, D2 = Y11. − Y13. = 1.4, D3 = Y12. − Y13. = −10.6,D4 = Y21. − Y22. = −12.8, D5 = Y21. − Y23.

= −7.8, D6 = Y22. − Y23.

= 5.0,D7 = Y31. − Y32. = −.6, D8 = Y31. − Y33. = 10.6, D9 = Y32. − Y33. = 11.2,s{Di} = 4.5612 (i = 1, ..., 9), B = t(.99167; 36) = 2.511 12.0± 2.511(4.5612) .547 ≤ D1 ≤ 23.4531.4± 2.511(4.5612) −10.053 ≤ D2 ≤ 12.853 −10.6± 2.511(4.5612) −22.053 ≤ D3 ≤ .853−12.8± 2.511(4.5612) −24.253 ≤ D4 ≤ −1.347−7.8± 2.511(4.5612) −19.253 ≤ D5 ≤ 3.653 5.0± 2.511(4.5612) −6.453 ≤ D6 ≤ 16.453−.6± 2.511(4.5612) −12.053 ≤ D7 ≤ 10.85310.6± 2.511(4.5612) −.853 ≤ D8 ≤ 22.05311.2± 2.511(4.5612) −.253 ≤ D9 ≤ 22.653 d. Y... = 55.8222, 90Y... = 5, 024, s{90Y...} = 96.7574, t(.995; 36) = 2.7195, 5, 024± 2.7195(96.7574), 4, 760.87 ≤ 90μ.. ≤ 5, 287.13 e. L = 10μ11 + 10μ13 + 10μ22 + 10μ23 + 10μ31 + 10μ32 − 20μ12 − 20μ21 − 20μ33, L = 650, s{L} = 136.8357, t(.995; 36) = 2.7195, 650± 2.7195(136.8357), 277.875 ≤ L ≤ 1, 022.125 f.

i j 1/Yij. log10Yij. 1 1 .0167 1.7771 2 .0209 1.6791 3 .0171 1.7662 1 .0207 1.6852 2 .0163 1.7872 3 .0178 1.7503 1 .0166 1.7803 2 .0164 1.7843 3 .0202 1.695 19.34. a. s{Y¯22.} = .1006, t(.975; 54) = 2.005, .58096± 2.005(.1006), .37926 ≤ µ22 ≤ .78266 b. D = .46816, s{D} = .1423, t(.975; 54) = 2.005, .46816± 2.005(.1423), .18285 ≤ D ≤ .75347 c. Y¯1.. = .78672, Y¯2.. = .61519 Y¯.1. = .42086, Y¯.2. = .69547, Y¯.3. = .98655 d. B = t(.9875; 54) = 2.306, q(.95; 2, 54) = 2.84, T = 2.008, q(.95; 3, 54) = 3.41, T = 2.411, F (.90; 3, 54) = 2.20, S = 2.569 e. D1 = Y¯1.. − Y¯2.. = .17153 s{D1} = .0822, s{Di} = .1006 (i = 2, 3, 4), B = 2.306 19.8 .17153± 2.306(.0822) −.0180 ≤ D1 ≤ .3611 −.27461± 2.306(.1006) −.5066 ≤ D2 ≤ −.0426 −.56569± 2.306(.1006) −.7977 ≤ D3 ≤ −.3337 −.29108± 2.306(.1006) −.5231 ≤ D4 ≤ −.0591 f. L = .0680, s{L} = .0711, t(.975; 54) = 2.005 ...

d.

L = −1.500, s{L} = 2.669, t(.975; 8) = 2.306, −1.500± 2.306(2.669), −7.655 ≤ L ≤ 4.655 e. H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F ∗ = 306.25/7.125 = 42.98, F (.99; 1, 8) = 11.3. If F ∗ ≤ 11.3 conclude H0, otherwise Ha. Conclude Ha. 19.37. n = 21 19.38. ∆/σ = 2, 2n = 8, n = 4 19.39. n = 21 19.40. .5√ n/.29 = 4.1999, n = 6 19.41. n = 14 19.42.

8√ n/9.1 = 3.1591, n = 13 19.43. Using (19.4) and (19.5), we have: µij = µ.. + αi + βj = µ.. + (µi. − µ..) + (µ.j − µ..) ...

Q = ∑∑∑ (Yijk − µij)2 ∂Q ∂µij = 2∑ k (Yijk − µij)(−1) 19-10 Setting the derivatives equal to zero, simplifying, and solving for the least squares estimators yields: µ̂ij = ∑k Yijk n = Yij. 19.47 ...

Y1.. = 2.4336, Y2.. = 2.8536 Y.1. = 2.5836, Y.2. = 2.7036 b.Source SS df MSA 1.2348 1 1.2348B .1008 1 .1008AB .1183 1 .1183Error .5341 24 .0223Total 1.9880 27 19-12 c. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F ∗ = .1183/.0223 = 5.32, F (.95; 1, 24) = 4.26. If F ∗ ≤ 4.26 conclude H0, otherwise Ha. Conclude Ha. P -value = .030 d. (i) Test for factor A (region effect) H0: α1 = α2 = 0, Ha: not both α1 and α2 equal zero.

F ∗ = 1.2348/.0223 = 55.48, F (.95; 1, 24) = 4.26. If F ∗ ≤ 4.26 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ (ii) Test for factor B (% below poverty) H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F ∗ = .1008/.0223 = 4.52, F (.95; 1, 24) = 4.26. If F ∗ ≤ 4.26 conclude H0, otherwise Ha. Conclude Ha. P -value = .044 e. α ≤ .143 19.57 b. D1 = Y¯11. − Y¯21. = 1.0506, D2 = Y¯11. − Y¯12. = 1.1538, D3 = Y¯11. − Y¯22. = 2.6431 ...

... Chapter 20 TWO-FACTOR STUDIES – ONE CASE PER TREATMENT 20.1. 0 20.2. b. Source SS df MSLocation 37.0050 3 12.3350Week 47.0450 1 47.0450Error .3450 3 .1150Total 84.3950 7 H0: all αi equal zero (i = 1, ..., 4), Ha: not all αi equal zero.

F ∗ = 12.3350/.1150 = 107.26, F (.95; 3, 3) = 9.28. If F ∗ ≤ 9.28 conclude H0, otherwise Ha. Conclude Ha. P -value = .0015 H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F ∗ = 47.0450/.1150 = 409.09, F (.95; 1, 3) = 10.1. If F ∗ ≤ 10.1 conclude H0, otherwise Ha. Conclude Ha. P -value = .0003. α ≤ .0975 c. D1 = Y¯2. − Y¯1. = −4.40, ...

... Source SS df MSBlocks 1.41896 4 .35474Fat content 1.32028 2 .66014Error .01932 8 .002415Total 2.75856 14 b. Y1 = 1.110, Y.2 = .992, Y.3 = .430 c. H0: all τj equal zero (j = 1, 2, 3), Ha: not all τj equal zero. F ∗ = .66014/.002415 = 273.35, F (.95; 2, 8) = 4.46. If F ∗ ≤ 4.46 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ d. D1 = .118, D2 = .562, s{Di} = .03108 (i = 1, 2), B = t(.9875; 8) = 2.7515 ...

... Chapter 22 ANALYSIS OF COVARIANCE 22.5. a. B = t(.9917; 11) = 2.820 22.6. Yij = µ. + τi + γ1(Xij1 − X..1) + γ2(Xij2 − X..2) + γ3(Xij1 − X..1)2 + γ4(Xij2 − X..2)2 + εij, i = 1, ..., 4 22.7. a. eij: ...

... Chapter 23 TWO-FACTOR STUDIES WITH UNEQUAL SAMPLE SIZES 23.3. a. Yijk = µ.. + α1Xijk1 + β1Xijk2 + (αβ)11Xijk1Xijk2 + εijk ...

... Full model: Y = .69199 + .08407X1 − .27492X2 − .01281X3 − .05706X1X2 + .01355X1X3, SSE(F) = 5.3383 Reduced model: Y = .69092 + .08407X1 − .27745X2 − .01305X3, SSE(R) = 5.4393 H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F ∗ = (.1010/2) ÷ (5.3383/51) = .48, F (.95; 2, 51) = 3.179. If F ∗ ≤ 3.179 conclude H0, otherwise Ha. Conclude H0. P -value = .62 ...

... Subject matter: Yijk = µ.. + α1Xijk1 + β1Xijk2 + β2Xijk3 + β3Xijk4 + β4Xijk5 + (αβ)11Xijk1Xijk2 + (αβ)12Xijk1Xijk3 + (αβ)13Xijk1Xijk4 + (αβ)14Xijk1Xijk5 + εijk ... Full model: Y = 2.72074 − .59611X1 + .48142X2 − .39964X3 − .33756X4 − .26317X5 ... H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. ... If F ∗ ≤ 2.492 conclude H0, otherwise Ha. Conclude H0. P -value = ... Ha: µ32 ≠ ...

p33 6= 0. D = Y32. − Y33. = −2.975, s{D} = .1790, t* = −2.975/.1790 = −16.62, t(.99; 24) = 2.492. If |t*| ≤ 2.492 conclude H0, otherwise Ha. Conclude Ha. α ≤ .04 23.13. a. Yijk = μ.. + α1Xijk1 + β1Xijk2 + β2Xijk3 + εijk Xijk1 = {1 if case from level 1 for factor A −1 if case from level 2 for factor A Xijk2 = {1 if case from level 1 for factor B −1 if case from level 3 for factor B 0 otherwise Xijk3 = {1 if case from level 2 for factor B −1 if case from level 3 for factor B 0 otherwise 23-12 Y = .66939 + .11733X1 − .34323X2 + .02608X3, SSE(F) = 4.4898 Factor A: Yijk = μ.. + β1Xijk2 + β2Xijk3 + εijk Y = .70850 − .26502X2 − .01303X3, SSE(R) = 5.0404 Factor B: Yijk = μ.. + α1Xijk1 + εijk Y = .77520 + .03152X1, SSE(R) = 7.1043 b. H0: α1 = 0, Ha: α1 6= 0. F* = (.5506/1)/(4.4898/46) = 5.641, F(.95; 1, 46) = 4.05. If F* ≤ 4.05 conclude H0, otherwise Ha. Conclude Ha. P-value = .022 H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F* = (2.6145/2)/(4.4898/46) = 13.393, F(.95; 2, 46) = 3.20. If F* ≤ 3.20 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ 23.14. a. See Problem 19.20a. D1 = Y12. − Y11. = 46.0, D2 = Y22. − Y23. = 6.0, L1 = D1 − D2 = 40.0, MSE = 88.50, s{D1} = s{D2} = 6.652, s{L1} = 9.407, B = t(.99167; 15) = 2.694 46.0± 2.694(6.652) 28.080 ≤ D1 ≤ 63.920 6.0± 2.694(6.652) −11.920 ≤ D2 ≤ 23.920 40.0± 2.694(9.407) 14.658 ≤ L1 ≤ 65.342 b. H0: μ22 − μ23 ≤ 0, Ha: μ22 − μ23 > 0. D = Y22. − Y23. = 6.0, s{D} = 6.652, t* = 6.0/6.652 = .902, t(.95; 15) = 1.753. If t* ≤ 1.753 conclude H0 otherwise Ha. Conclude H0. P-value = .19 23.15. a. Yijk = μ.. + α1Xijk1 + α2Xijk2 + α3Xijk3 + β1Xijk4 + β2Xijk5 + εijk Xijk1 = {1 if case from level 1 for factor A −1 if case from level 4 for factor A 0 otherwise Xijk2 and Xijk3 are defined similarly Xijk4 = {1 if case from level 1 for factor B−1 if case from level 3 for factor B 0 otherwise Xijk5 = {1 if case from level 2 for factor B−1 if case from level 3 for factor B 0 otherwise Y = 2.71932 − .59897X1 + .08546X2 + .40036X3 − .34043X4 − .26218X5, SSE(F) = .7419 Factor A: 23-13 Yijk = μ.. + β1Xijk4 + β2Xijk5 + εijk Y = 2.77494− .22494X4 − .23648X5, SSE(R) = 5.8217 Factor B: Yijk = μ.. + α1Xijk1 + α2Xijk2 + α3Xijk3 + εijk Y = 2.90108− .35108X1 + .11460X2 + .33529X3, SSE(R) = 8.1874 b. H0: α1 = α2 = α3 = 0, Ha: not all αi equal zero. F* = (5.0798/3)/(.7419/37) = 84.45, F(.99; 3, 37) = 4.360. If F* ≤ 4.360 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F* = (7.4455/2)/(.7419/37) = 185.66, F(.99; 2, 37) = 5.229. If F* ≤ 5.229 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ 23.16. a. Yijk = μ.. + ρ1Xijk1 + ρ2Xijk2 + ρ3Xijk3 + ρ4Xijk4 + ρ5Xijk5 + ρ6Xijk6 + ρ7Xijk7 + ρ8Xijk8 + ρ9Xijk9 + τ1Xij10 + τ2Xij11 + εij Xij1 = {1 if experimental unit received treatment 1−1 if experimental unit received treatment 3 0 otherwise Xij10 = {1 if experimental unit from block 1−1 if experimental unit from block 10 0 otherwise Xij2, . . . , Xij9 are defined similarly Xij11 = {1 if experimental unit received treatment 2−1 if experimental unit received treatment 3 0 otherwise b. Y = 7.10000 + 4.90000X1 + 3.90000X2 + 2.23333X3 + 2.23333X4 + 1.23333X5 + .90000X6 − 1.10000X7 − 3.76667X8 − 4.10000X9 − 6.50000X10 + 2.50000X11 c. Source SS df MS Regression 1, 728.3667 1 157.1224 X1, X2, X3, X4, X5, X6,X7, X8,X9 433.3667 9 48.1519X10, X11|X1, X2, X3, X4, X5, X6,X7, X8,X9 1, 295.0000 2 647.5000Error 112.3333 18 6.2407Total 1, 840.7000 29 d. H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F* = (1, 295.0000/2)/(112.3333/18) = 103.754, F(.95; 2, 18) = 3.55. If F* ≤ 3.55 conclude H0, otherwise Ha. Conclude Ha. 23.17. a. Yij = μ.. + ρ1Xij1 + ρ2Xij2 + ρ3Xij3 + ρ4Xij4 + τ1Xij5 + τ2Xij6 + εij 23-14 Xij1 = {1 if experimental unit from block 1−1 if experimental unit from block 5 0 otherwise Xij2, . . . , Xij4 are defined similarly Xij5 = {1 if experimental unit received treatment 1−1 if experimental unit received treatment 3 0 otherwise Xij6 = {1 if experimental unit received treatment 2−1 if experimental unit received treatment 3 0 otherwise b. Y = .84400 − .32733X1 − .23733X2 − .11400X3 + .31267X4 − .26600X5 + .14800X6 c. Source SS df MS Regression 2.7392 6 .45653X1, X2, X3, X4 1.4190 4 .35475X5, X6 | X1, X2, X3, X4 1.3203 2 .66015Error .0193 8 .00241Total 2.7585 14 d. H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F* = (1.3203/2)/(.0193/8) = 273.637, F(.95; 2, 8) = 4.46. If F* ≤ 4.46 conclude H0, otherwise Ha. Conclude Ha. 23.18. a. Yij = μ.. + ρi + τj + εij Yij = μ.. + ρ1Xij1 + ρ2Xij2 + ρ3Xij3 + ρ4Xij4 + ρ5Xij5 + ρ6Xij6 + ρ7Xij7 + ρ8Xij8 + ρ9Xij9 + τ1Xij10 + τ2Xij11 + εij Xij1 = {1 if experimental unit from block 1−1 if experimental unit from block 10 0 otherwise Xij2, . . . , Xij9 are defined similarly Xij10 = {1 if experimental unit received treatment 1−1 if experimental unit received treatment 3 0 otherwise Xij11 = {1 if experimental unit received treatment 2−1 if experimental unit received treatment 3 0 otherwise Full model: Y = 77.15556 + 4.84444X1 + 4.40000X2 + 2.17778X3 + 3.17778X4 + 1.17778X5 + .84444X6 − 1.15556X7 −3.82222X8 − 4.15556X9 − 6.55556X10 − 2.55556X11 23-15 SSE(F) = 110.6667 Reduced model: Y = 76.70000 + 5.30000X1 + .30000X2 + 2.63333X3 + 3.63333X4 + 1.63333X5 + 1.30000X6 − .70000X7 −3.36667X8 − 3.70000X9 SSE(R) = 1, 311.3333 H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F* = (1, 200.6666/2)/(110.6667/17) = 92.22, F(.95; 2, 17) = 3.59. If F* ≤ 3.59 conclude H0, otherwise Ha. Conclude Ha. d. L = τ2 − τ3 = 2τ2 + τ1 = −11.66667, s2{τ1} = .44604 (i = 1, 2), s{τ1, τ2} = −.20494, s{L} = 1.1876, t(.975; 17) = 2.11, −11.66667± 2.11(1.1876) −14.17 ≤ L ≤ −9.16 23.19. a. Yij = μ.. + ρi + τj + εij Yij = μ.. + ρ1Xij1 + ρ2Xij2 + ρ3Xij3 + ρ4Xij4 + τ1Xij5 + τ2Xij6 + εij Xij1 = {1 if experimental unit from block 1−1 if experimental unit from block 5 0 otherwise Xij2, . . . , Xij4 are defined similarly Xij5 = {1 if experimental unit received treatment 1−1 if experimental unit received treatment 3 0 otherwise Xij6 defined similarly Xij6 = {1 if experimental unit received treatment 2−1 if experimental unit received treatment 3 0 otherwise b.

Yij = μ.. + ρ1Xij1 + ρ2Xij2 + ρ3Xij3 + ρ4Xij4 + εij c. Full model: Y = .82914 − .33613X1 − .22274X2 − .11941X3 + .32726X4 + .25083X5 + .16259X6 SSE(F) = .0035 Reduced model: Y = .84567 − .14567X1 − .23900X2 − .17567X3 + .31100X4 SSE(R) = .9542 H0: τ1 = τ2 = 0, Ha: not both τ1 and τ2 equal zero. F* = (.9507/2)/(.0035/6) = 814.89, F(.95; 2, 6) = 5.14. If F* ≤ 5.14 conclude H0, otherwise Ha. Conclude Ha. d. L = τ1 − τ3 = 2τ1 + τ2 = .66429, s2{τ1} = .000105, s2{τ2} = .000087, s{τ1, τ2} = −.000043, s{L} = .0183, t(.95; 6) = 3.143, .66429± 3.143(.0183) .607 ≤ L ≤ .722 23.20. See Problem 19.10a. L1 = .3μ11 + .6μ21 + .1μ31, L2 = .3μ12 + .6μ22 + .1μ32. 23-16 H0: L1 = L2, Ha: L1 6= L2 L1 − L2 = 25.43332 − 25.05001 = .38331, MSE = 2.5889, s{L1 − L2} = .6052, t* = .38331/.6052 = .633, t(.995; 30) = 2.042. If |t*| ≤ 2.042 conclude H0, otherwise Ha. Conclude H0. P-value = .53 23.21. a. H0:L1 = 3μ11 + μ21 − 4μ12 = 0, L2 = 3μ11 + μ21 − 4μ13 = 0 Ha: not both L1 and L2 equal zero b. Regression model equivalent to (19.15) using 1, 0 indicator variables: Full model: Yijk = μ11Xijk1 + μ12Xijk2 + μ13Xijk3 + μ21Xijk4 + μ22Xijk5 +μ23Xijk6 + εijk Xijk1 = {1 if case from level 1 for factor A and level 1 for factor B0 otherwise Xijk2 = {1 if case from level 1 for factor A and level 2 for factor B0 otherwise Xijk3 = {1 if case from level 1 for factor A and level 3 for factor B0 otherwise Xijk4 = {1 if case from level 2 for factor A and level 1 for factor B0 otherwise Xijk5 = {1 if case from level 2 for factor A and level 2 for factor B0 otherwise Xijk6 = {1 if case from level 2 for factor A and level 3 for factor B0 otherwise c. Reduced model: μ11 = μ12 + μ22/3− μ21/3 μ13 = μ12 + μ22/3− μ23/3 Yijk = (μ12 + μ22/3− μ21/3)Xijk1 + μ12Xijk2 + (μ12 + μ22/3− μ23/3)Xijk3 + μ21Xijk4 + μ22Xijk5 + μ23Xijk6 + εijk or Yijk = μ12Zijk1 + μ21Zijk2 + μ22Zijk3 + μ23Zijk4 + εijk where: Zijk1 = Xijk1 + Xijk2 + Xijk3 Zijk2 = −Xijk1/3 + Xijk4 Zijk3 = (Xijk1 + Xijk3)/3 + Xijk5 Zijk4 = −Xijk3/3 + Xijk6 23-17 d.

SSE(F) = 5.468, dfF = 54 SSE(R) = 8.490, dfR = 56, F* = [(8.490− 5.468)/2]/(5.468/54) = 14.92, F(.95; 2, 54) = 3.17. If F* ≤ 3.17 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ 23.22. a. See Problem 19.18a. L2 = (.75Y11. + .25Y21.) − (.75Y13. + .25Y23.) = −.61446, s{L2} = .1125, t(.975; 54) = 2.005, −.61446± 2.005(.1125), −.840 ≤ L2 ≤ −.389 23.22. a. L1 = μp11 + 2μ12 + 7μ13 10 − μ21 + 2μ22 + 7μ23 10 = H0: L2 = μp11 + 2μ12 + 7μ13 10− μ21 + 2μ22 + 7μ23 10 = 0 L3 = μp11 + 2μ12 + 7μ13 10− μp41 + 2μ42 + 7μp43 10 = 0 Ha: not all Li equal zero (i = 1, 2, 3) b. β entries: μ11, μ12, μ13, μ21, μ22, μ23, μ31, μ32, μ33, μ41, μ42, μ43 X entries: A B Freq.] 1 1 0 0 0 0 0 0 0 0 0 0 0 1 2 0 1 0 0 0 0 0 0 0 0 0 0 1 3 0 0 1 0 0 0 0 0 0 0 0 0 2 1 0 0 0 1 0 0 0 0 0 0 0 0 ... C = 1 −.2 −.7 1 −.2 −.7 0 0 0 0 0 0 ... SSE(R) = 5.6821 vs SSE(F) = .7180, F* = (5.6821/3)/(.7180/33) = 87.05, F(.99; 3, 33) = 4.437. If F* ≤ 4.437 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ f. See Problem 23.10a. L2 = (.1Y11. + .2Y12. + .7Y13.) − (.1Y31. + .2Y32. + .7Y33.) = −1.1652, s{L2} = .06558, t(.95; 33) = 1.692 ... 23.23. H0:μ11 + μ12 + μ13 = 4μ21 + 4μ22 + 4μ23 ... 143, Y2.. = 48.91 SSA = 10(143− 93.714)2 + 11(48.91− 93.714)2 = 46, 372 23-18 F* = (46, 372/1)/(1, 423.1667/15) = 488.8, F(.99; 1, 15) = 8.68. If F* ≤ 8.68 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ 23.24. H0:212 μ11 + 212 μ12 + 812 μ13 = 413 μ21 + 513 μ22 + 413 μ23 = 211 μ31 + 411 μ32 + 511 μ33 =29μ41 + 29μ42 + 59μ43, Ha: not all equalities hold. Y... = 2.849, Y1.. = 2.425, Y2.. = 2.785, Y3.. = 3.236, Y4.. = 3.033 SSA = 12(2.425 − 2.849)2 + 13(2.785 − 2.849)2 + 11(3.236 − 2.849)2 + 9(3.033 − 2.849)2 = 4.163 F* = (4.163/3)/(.718/33) = 63.78, F(.95; 3, 33) = 2.89. If F* ≤ 2.89 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ 23.25. σ2{L} = σ2(∑ cijμij) = ∑ c2ij σ2{μij} = ∑ c2ij σ2/nij, s2{L} = MSE ∑ c2ij/nij = b1 b2 ∑i c2i ∑j n1 nij σ2 b2 ∑i c2i ∑j 1 nij because of independence of Yij.. 23.26. E{s2{L} } = E {MSE ∑ c2ij nij } = ∑ ∑ c2ij nij E{MSE} = σ2 ∑ ∑ c2ij nij = σ2{L} 23.27. a. X = 1 1 0 1 0 1 0 0 1 1 ... Xβ = β0 + β1 + β3 β0 + β1 + β4 β0 + β1 β0 + β2 + β3 β0 + β2 + β4 β0 + β2 β0 + β3 β0 + β4 β0 = μ.. + ρ1 + τ1 μ.. + ρ1 + τ2 μ.. + ρ1 + τ3 μ.. + ρ2 + τ1 μ.. + ρ2 + τ2 μ.. + ρ2 + τ3 μ.. + ρ3 + τ1 μ.. + ρ3 + τ2 μ.. + ρ3 + τ3 β0 = μ.. + ρ3 + τ3 β1 = ρ1 − ρ3 β2 = ρ2 − ρ3 β3 = τ1 − τ3 β4 = τ2 − τ3 23-19 23.28. Y = Y111 Y112 Y121 Y122 Y211 Y212 Y221 X = 1 0 0 0 1 0 0 0 ... β = μ11 μ12 μ21 μ22 bF = Y11. Y12. Y21. Y22. Cβ = [1 −1 −1 1] μ11 μ12 μ21 μ22 = μ11 − μ12 − μ21 + μ22 = 0 From (23.46): bR = Y11. Y12. Y21. Y22. − 1/2 0 0 0 1/2 0 0 0 1/2 0 0 0 0 1/2 ... Y = {Y11. − Y12. − Y21. + Y22.} ...

a. β entries: μ11, μ12, μ13, μ22 X entries:A B Freq.] 1 1 1 0 0 0 1 2 0 1 0 0 1 3 0 0 1 0 2 1 ... 23.30. a. Yijk = μ.. + αi + βj + (αβ)ij + εijk Yijk = μ.. + α1Xijk1 + α2Xijk2 + α3Xijk3 + β1Xijk4 + β2Xijk5 + (αβ)11Xijk1Xijk4 + (αβ)12Xijk1Xijk5 + (αβ)21Xijk2Xijk4 + (αβ)22Xijk2Xijk5 + (αβ)31Xijk3Xijk4 + (αβ)32Xijk3Xijk5 + εijk Xijk1 = {1 if case from NE−1 if case from W 0 otherwise Xijk2 = {1 if case from NC−1 if case from W 0 otherwise Xijk3 = {1 if case from S−1 if case from W 0 otherwise 23-20 Xijk4 = {1 if average age under 52.0−1 if average age 55.0 or more 0 otherwise Xijk5 = {1 if average age 52.0 − 55.0−1 if average age 55.0 or more 0 otherwise b. Y = 9.40661 + 1.45009X1 + .23601X2 − .24406X3 − .38373X4 + .19446X5 − .76296X1X4 − .57198X1X5 + .44674X2X4 + .17515X2X5 + .35707X3X4 − .38986X3X5, SSE(F) = 261.2341 c. r = .959 23.31. a. Y11. = 9.71000, Y12. = 10.47917, Y13. = 12.38091, Y21. = 9.70563, Y22. = 10.01222, Y23. = 9.21000, Y31. = 9.13588, Y32. = 8.96714, Y33. = 9.38462, Y41. = 7.54000, Y42. = 8.94571, Y43. = 7.40800 b. Yijk = μ.. + α1Xijk1 + α2Xijk2 + α3Xijk3 + β1Xijk4 + β2Xijk5 + εijk c. Y = 9.52688 + 1.50561X1 + .23119X2 − .30781X3 − .26423X4 − .00518X5, SSE(R) = 300.4100 H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = (39.1759/6)/(261.2341/101) = 2.524, F(.95; 6, 101) = 2.19. If F* ≤ 2.19 conclude H0, otherwise Ha. Conclude Ha. P-value = .026 d. Yijk = μ.. + β1Xijk4 + β2Xijk5 + (αβ)11Xijk1Xijk4 + (αβ)12Xijk1Xijk5 + (αβ)21Xijk2Xijk4 + (αβ)22Xijk2Xijk5 + (αβ)31Xijk3Xijk4 + (αβ)32Xijk3Xijk5 + εijk Y = 9.52473 − .50240X4 + .24409X5 − 1.44778X1X4 − .17942X1X5 + .63345X2X4 + .11924X2X5 + .34296X3X4 − .24453X3X5, SSE(R) = 345.4833 H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F* = (84.2492/3)/(261.2341/101) = 10.858, F(.99; 3, 101) = 3.98. If F* ≤ 3.98 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ e. Yijk = μ.. + α1Xijk1 + α2Xijk2 + α3Xijk3 + (αβ)11Xijk1Xijk4 + (αβ)12Xijk1Xijk5 + (αβ)21Xijk2Xijk4 + (αβ)22Xijk2Xijk5 + (αβ)31Xijk3Xijk4 + (αβ)32Xijk3Xijk5 + εijk Y = 9.52473 + 1.50240X1 + .24409X2 ... SSE(R) = 262.8860 H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F* = (6.4762/2)/(261.2341/101) = 1.252, F(.99; 2, 101) = 4.82. If F* ≤ 4.82 conclude H0, otherwise Ha. Conclude H0. P-value = .29 f. n11 = 5, n12 = 12, n13 = 11, n21 = 16, n22 = 9, n23 = 7, n31 = 17, n32 = 7, n33 = 13, n41 = 4, n42 = 7, n43 = 5, D1 = μ1. − μ2. = 10.85669− 9.64262 = 1.21407, D2 = μ1. − μ3. = 10.85669− 9.16255 = 1.69414, D3 = μ1. − μ4. = 10.85669− 7.96457 = 2.89212, D4 = μ2. − μ3. = .48007, D5 = μ2. − μ4. = 1.67805, D6 = μ3. − μ4. = 1.19798, MSE = 2.5865, s{D1} = .4455, s{D2} = .4332, s{D3} = .5272, s{D4} = .4135, s{D5} = .5004, q(.95; 4, 101) = 3.694, T = 2.612 1.21407± 2.612(.4455) .050 ≤ D1 ≤ 2.378 1.69414± 2.612(.4332) .563 ≤ D2 ≤ 2.826 2.89212± 2.612(.5272) 1.515 ≤ D3 ≤ 4.269 .48007± 2.612(.4135) −.600 ≤ D4 ≤ 1.560 1.67805± 2.612(.5112) .343 ≤ D5 ≤ 3.013 1.19798± 2.612(.5004) −.109 ≤ D6 ≤ 2.505 23.32. a. ANOVA model: Yijk = μ.. + αi + βj + (αβ)ij + εijk Regression: Yijk = μ.. + α1Xijk1 + α2Xijk2 + α3Xijk3 + β1Xijk4 + β2Xijk5 + (αβ)11Xijk1Xijk4 + (αβ)12Xijk1Xijk5 + (αβ)21Xijk2Xijk4 + (αβ)22Xijk2Xijk5 + (αβ)31Xijk3Xijk4 + (αβ)32Xijk3Xijk5 + εijk Xijk1 = {1 if case from NE−1 if case from W 0 otherwise Xijk2 = {1 if case from NC−1 if case from W 0 otherwise Xijk3 = {1 if case from S−1 if case from W 0 otherwise Xijk4 = {1 if poverty level below 6.0 percent −1 if poverty level is 10 percent or more 0 otherwise Xijk5 = {1 if poverty level between 6.0 and under 10.0 percent−1 if poverty level is 10 percent or more 0 otherwise 23-22 b. Y = .05663 − .00526X1 − .00475X2 + .00983X3 − .01114X4 − .00173X5 − .00260X1X4 + .00623X1X5 + .00069X2X4 − .00198X2X5 + .00133X3X4 − .00133X3X5, SSE(F) = .23111 c. r = .932 23.33. a. Y11. = .0348, Y12. = .0402, Y13. = .0697, Y21. = .0396, Y22. = .0510, Y23. = .0655, Y31. = .0542, Y32. = .0662, Y33. = .0794, Y41. = .0500, Y42. = .0627, Y43. = .0649 b. Yijk = μ.. + α1Xijk1 + α2Xijk2 + α3Xijk3 + β1Xijk4 + β2Xijk5 + εijk c. Y = .0562 − .0105X1 − .0032X2 + .0100X3 − .0117X4 − .0013X5, SSE(R) = .23589 H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = (.00478/6)/(.23111/428) = 1.476, F(.995; 6, 428) = 3.14.

If F* ≤ 3.14 conclude H0, otherwise Ha. Conclude H0. P-value = .18 d. Yijk = μ.. + β1Xijk4 + β2Xijk5 + (αβ)11Xijk1Xijk4 + (αβ)12Xijk1Xijk5 + (αβ)21Xijk2Xijk4 + (αβ)22Xijk2Xijk5 + (αβ)31Xijk3Xijk4 + (αβ)32Xijk3Xijk5 + εijk Y = .0578− .0141X4 − .0024X5 − .0004X1X4 − .0090X1X5 + .0020X2X4 − .0005X2X5 − .0040X3X4 − .0039X3X5, SSE(R) = .25118 H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F* = (.02007/3)/(.23111/428) = 12.39, F(.995; 3, 428) = 4.34. If F* ≤ 4.34 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ e. Yijk = μ.. + α1Xijk1 + α2Xijk2 + α3Xijk3 + (αβ)11Xijk1Xijk4 + (αβ)12Xijk1Xijk5 + (αβ)21Xijk2Xijk4 + (αβ)22Xijk2Xijk5 + (αβ)31Xijk3Xijk4 + (αβ)32Xijk3Xijk5 + εijk Y = .0558− .0138X1 − .0047X2 + .0135X3 − .0006X1X4 + .0065X1X5 + .0012X2X4 − .0022X2X5 + .0025X3X4 − .0025X3X5, SSE(R) = .26209 H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F* = (.03098/2)/(.23111/428) = 28.69, F(.995; 2, 428) = 5.36. If F* ≤ 5.36 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ f. n11 = 52, n12 = 18, n13 = 13, n21 = 22, n22 = 50, n23 = 26, n31 = 25, n32 = 52, n33 = 75, n41 = 20, n42 = 33, n43 = 24, D1 = μ1. − μ2. = −.0038, D2 = μ1. − μ3. = −.0184, D3 = μ1. − μ4. = −.0110, D4 = μ2. − μ3. = −.0146, D5 = μ2. − μ4. = −.0072, D6 = μ3. − μ4. = .0064, 23-23 MSE = .00054, q(.95; 4, 428) = 3.63, T = 2.567 s{D1} = .00357, s{D2} = .00342, s{D3} = .00383, s{D4} = .00312, s{D5} = .00356, s{D6} = .00342, −.0038± 2.567(.00357) −.0130 ≤ D1 ≤ .0054−.0184± 2.567(.00342) −.0271 ≤ D2 ≤ −.0096−.0110± 2.567(.00383) −.0218 ≤ D3 ≤ −.0021−.0146± 2.567(.00312) −.0226 ≤ D4 ≤ −.0066−.0082± 2.567(.00356) −.0173 ≤ D5 ≤ .0010 .0064± 2.567(.00342) −.0024 ≤ D6 ≤ .0152 23.34. a. ANOVA model: Yijk = μ.. + αi + βj + (αβ)ij + εijk Regression: Yijk = μ.. + α1Xijk1 + β1Xijk2 + (αβ)11Xijk1Xijk2 + εijk Xijk1 = {1 if no discount price (level 1 of variable 5) −1 if discount price (level 2 of variable 5) Xijk2 = {1 if no package promotion (level 1 of variable 6) −1 if package promotion (level 2 of variable 6) b. Y = 2.620 − .199X1 − .046X2 + .036X1X2 SSE(F) = .7850 c.

r = .990 23.35. a. Y00. = 2.4125, Y01. = 2.4286, Y10. = 2.7375, Y11. = 2.9000, b. Yijk = μ.. + α1Xijk1 + β1Xijk2 + εijk c. Y = 2.625− .201X1 − .0498X2, SSE(R) = .8306 H0: (αβ)11 = 0, Ha: (αβ)11 6= 0. F* = (.0456/1)/(.7850/32) = 1.86. F(.95; 1, 32) = 4.15. If F* ≤ 4.15 conclude H0, otherwise Ha. Conclude H0. P-value = .18 d. Yijk = μ.. + β1Xijk2 + (αβ)11Xijk1Xijk2 + εijk Y = 2.648− .0726X2 + .0494X1X2, SSE(R) = 2.1352 H0: α1 = 0, Ha: α1 6= 0. F* = (1.3502/1)/(.7850/32) = 55.04, F(.95; 1, 32) = 4.15. If F* ≤ 4.15 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ e. Yijk = μ.. + α1Xijk1 + (αβ)11Xijk1Xijk2 + εijk Y = 2.623− .205X1 + .0479X1X2, SSE(R) = .8579 H0: β1 = 0, Ha: β1 6= 0. F* = (.0679/1)/(.7850/32) = 2.77, F(.95; 1, 32) = 4.15. If F* ≤ 4.15 conclude H0, otherwise Ha. Conclude H0. P-value = .11 23-24 23.36. a. H0: μ11 + μ12 + μ21 + μ22 = 4μ, Ha: not all equalities hold ... SSE(R) = (261.23406/101) = 3.16, F(.99; 3, 101) = 3.98. If F* ≤ 3.98 conclude H0, otherwise Ha. Conclude H0. H0:5μ11+12μ12+11μ13 28 = 16μ21+9μ22+7μ23 32 = 17μ31+7μ32+13μ33 37 = 4μ41+7μ42+5μ43 16, Ha: not all equalities hold. Y... = 9.98, ... = (10.63980/2)/(261.23406/101) = 2.057, F(.99; 2, 101) = 4.82. If F* ≤ 4.82 conclude H0, otherwise Ha. Conclude H0. P-value = .13 23.37. a. H0:52μ11+18μ12+13μ13 83 = 22μ21+50μ22+26μ23 98 = 25μ31+52μ32+75μ33 152 = 20μ41+33μ42+24μ43 77, Ha: not all equalities hold. Y.... = .05729, Y1.. = .04123, Y2.. = .05111, Y3.. = .07074, Y4.. = .06088 ... F* = (.0592/3)/(.23111/428) = 36.54, F(.995; 3, 428) = 4.34. If F* ≤ 4.34 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ b. H0:52μ11+22μ21+25μ31+20μ41 119 = 18μ12+50μ22+52μ32+33μ42 153 = 13μ13+26μ23+75μ33+24μ43 138, Ha: not all equalities hold. Y... = .05729, Y.1. = .04259, Y.2. = .05544, Y.3. = .07334, F* = (.0640/2)/(.23111/428) = 59.26, F(.995; 2, 428) = 5.36. If F* ≤ 5.36 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ 23-25 23-26 Chapter 24 MULTIFACTOR STUDIES 24.1. a. β1 = μ.1. − μ.., β2 = μ.2. − μ.., β3 = μ.3. − μ.. b. (βγ)12 = μ.12 − μ.1. − μ..2 + μ... = 1 c. (αβγ)212 = μ212 − μ21. − μ2.2 − μ.12 + μ2.. + μ.1. + μ..2 − μ... = 1.5 24.4. a. α1 = μ1.. − μ... = 138 − 131.5 = 6.5, α2 = μ2.. − μ... = 131.5 − 131.5 = 0 α3 = μ3.. − μ... = 125 − 131.5 = −6.5 b. β2 = μ.2. − μ... = 134 − 131.5 = 2.5, γ1 = μ..1 − μ... = 128.5 − 131.5 = −3 c. (αβ)12 = μ12. − μ1.. − μ.2. + μ... = 141 − 138 − 134 + 131.5 = .5 (αγ)21 = μ2.1 − μ2.. − μ..1 + μ... = 0, (βγ)12 = μ.12 − μ.1. − μ..2 + μ... = 1 d. (αβγ)111 = μ111 − μ11. − μ1.1 − μ.11 + μ1.. + μ.1. + μ..1 − μ... = 130 − 126 − 134 − 135 + 138 + 129 + 128.5 − 131.5 = −1 (αβγ)322 = μ322 − μ32. − μ3.2 − μ.22 + μ3.. + μ.2. + μ..2 − μ... = 131 − 128 − 126.5 − 137 + 125 + 134 + 134.5 − 131.5 = 1.5 24.6. a. eijkm: k = 1 i j = 1 j = 21 3.7667 1.1667 −3.9333 −1.6333.1667 .4667 2 −1.7000 −.83331.1000 1.3667.6000 −.5333 k = 2i j = 1 j = 2 1 −.5000 −1.0333 .4000 1.3667 .1000 −.3333 2 1.3667 .5667 −1.6667 1.7333 .5333 −1.1667 b. r = .973 24.7. a. Y111. = 36.1333, Y112. = 56.5000, Y121. = 52.3333, Y122. = 71.9333, Y211. = 46.9000, Y212. = 68.2667, Y221. = 64.1333, Y222. = 83.4667 24-1 b. Source SS df MSTreatments 4, 772.25835 7 681.75119A (chemical) 788.90667 1 788.90667B (temperature) 1, 539.20167 1 539.20167C (time) 2, 440.16667 1 2, 440.16667AB interactions .24000 1 .24000AC interactions .20167 1 .20167BC interactions 2.94000 1 2.94000ABC interactions .06000 1 .06000Error 53.74000 16 3.35875Total 4, 825.99835 23 c. H0: all (αβγ)ijk equal zero, Ha: not all (αβγ)ijk equal zero. F* = .06000/3.35875 =.18, F(.975; 1, 16) = 6.12.

If F* ≤ 6.12 conclude H0, otherwise Ha. Conclude H0. P-value = .68 d. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = .24000/3.35875 =.07, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. ConcludeH0.P -value = .79 H0: all (αγ)ik equal zero, Ha: not all (αγ)ik equal zero. F* = .20167/3.35875 =.06, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. Conclude H0.P -value = .81 H0: all (βγ)jk equal zero, Ha: not all (βγ)jk equal zero. F* = 2.94000/3.35875 = .88, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. ConcludeH0.P -value = .36 e. H0: all αi equal zero (i = 1, 2), Ha: not all αi equal zero. F* = 788.90667/3.35875 =234.88, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. ConcludeHa. P-value = 0+ H0: all βj equal zero (j = 1, 2), Ha: not all βj equal zero. F* = 1, 539.20167/3.35875 =458.27, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. ConcludeHa. P-value = 0+ H0: all γk equal zero (k = 1, 2), Ha: not all γk equal zero. F* = 2, 440.16667/3.35875 =726.51, F(.975; 1, 16) = 6.12. If F* ≤ 6.12 conclude H0, otherwise Ha. ConcludeHa. P-value = 0+ f. α ≤ .1624 24.8. a. D1 = 65.69167− 54.22500 = 11.46667, D2 = 67.96667− 51.95000 = 16.01667, D3 = 70.04167− 49.87500 = 20.16667, MSE = 3.35875, s{Di} = .7482 (i = 1, 2, 3), B = t(.99167; 16) = 2.673 11.46667± 2.673(.7482) 9.467 ≤ D1 ≤ 13.467 16.01667± 2.673(.7482) 14.017 ≤ D2 ≤ 18.017 20.16667± 2.673(.7482) 18.167 ≤ D3 ≤ 22.167 b.

Y222. = 83.46667, s{Y222.} = 1.0581, t(.975; 16) = 2.120, 24-2 83.46667± 2.120(1.0581), 81.2235 ≤ μ222 ≤ 85.7098 24.9. a. eijkm: k = 1 i j = 1 j = 21 2.250 −1.825 −1.450 2.975 −1.350 −1.525 .550 .375 2 −1.925 .950 −2.225 −.950 4.3753.550 −2.525 −2.950 .975.250 −2.825 k = 2i j = 1 j = 21 1.450 −4.475 −1.050 3.2252.050 3.725 −2.650 −2.575 2 2.625 1.00 −1.875.500 −2.075.100 1.325 −2.700 3 −1.350 −2.450.600 2.450 3.550 −1.250 −2.850 1.250 b. r = .974 24.10. a. Y111. = 121.050, Y112. = 111.250, Y121. = 116.925, Y122. = 92.675, Y211. = 121.225, Y212. = 110.975, Y221. = 116.250, Y222. = 90.600, Y311. = 91.750, Y312. = 79.950, Y321. = 85.525, Y322. = 61.050 b. Y1... = 110.7250, Y2... = 109.7625, Y3... = 79.5688 c. Source SS df MSTreatments 16, 291.75564 11 1, 481.06870A (fee) 10, 044.27125 2 5, 022.13563B (scope) 1, 833.97688 1 1, 833.97688C (supervision) 3, 832.40021 1 3, 832.40021AB interactions 1.60125 2 .80062AC interactions .78792 2 .39396BC interactions 574.77521 1 574.77521ABC interactions 3.94292 2 1.97146Error 266.13750 36 7.39271Total 16, 557.89314 47 d. H0: all (αβγ)ijk equal zero, Ha: not all (αβγ)ijk equal zero. F* = 1.97146/7.39271 =.27, F(.99; 2, 36) = 5.25. If F* ≤ 5.25 conclude H0, otherwise Ha. Conclude H0. P-value = .77 e. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = .80062/7.39271 =.11, F(.99; 2, 36) = 5.25. If F* ≤ 5.25 conclude H0, otherwise Ha. Conclude H0.P -value = .90 24-3 H0: all (αγ)ik equal zero, Ha: not all (αγ)ik equal zero. F* = .39396/7.39271 =.05, F(.99; 2, 36) = 5.25. If F* ≤ 5.25 conclude H0, otherwise Ha. Conclude H0.P -value = .95 H0: all (βγ)jk equal zero, Ha: not all (βγ)jk equal zero. F* = 574.77521/7.39271 =77.75, F(.99; 1, 36) = 7.40. If F* ≤ 7.40 conclude H0, otherwise Ha. ConcludeHa. P-value = 0+ f. H0: all αi equal zero (i = 1, 2, 3), Ha: not all αi equal zero. F* = 5, 022.13563/7.39271 =679.33, F(.99; 2, 36) = 5.25.

If F* ≤ 5.25 conclude H0, otherwise Ha. ConcludeHa. P-value = 0+ g. α ≤ .049 24.11. a. D1 = .9625, D2 = 30.1937, D3 = 31.1562, D4 = 111.6750 − 100.7250 = 10.9500 D5 = 106.2333 − 81.4417 = 24.7916, L1 = −13.8416, s{D1} = .9613 (i = 1, 2, 3), s{D4} = s{D5} = 1.1100, s{L1} = 1.5698, B = t(.99167; 36) = 2.511 .9625± 2.511(.9613) −1.451 ≤ D1 ≤ 3.376 30.1937± 2.511(.9613) 27.780 ≤ D2 ≤ 32.608 31.1562± 2.511(.9613) 28.742 ≤ D3 ≤ 33.570 10.9500± 2.511(1.1100) 8.163 ≤ D4 ≤ 13.737 24.7916± 2.511(1.1100) 22.004 ≤ D5 ≤ 27.579 −13.8416± 2.511(1.5698) −17.783 ≤ L1 ≤ −9.900 b. D = 116.925− 116.250 = .675, s{D} = 1.9226, t(.975; 36) = 2.028, .675± 2.028(1.9226), −3.224 ≤ D ≤ 4.574 c. s{D} = 1.9226, q(.90; 12, 36) = 4.52, T = 3.196, Ts{D} = 6.14, Y111. = 122.050, Y211. = 121.225, Y121. = 116.925, Y221. = 116.250 24-4 Y112. = 111.250 Y212. = 110.975 24.12. a. eijkm: k = 1 i j = 1 j = 2 1 −.4 1.8 −1.6 −.2 −.8 1.0 2 −.2 ... 24.13. a. Y111. = 1, 218.6, Y112. = 1, 051.0, Y121. = 1, 274.2, Y122. = 1, 122.4, Y131. = 1, 218.2, Y132. = 1, 251.2, Y211. = 1, 036.4, Y212. = 870.6, Y221. = 1, 077.4, Y222. = 931.6, Y231. = 1, 020.4, Y232. = 860.4 b.

r = .991 24-5 b. Source SS df MS Treatments 973, 645.933 11 88, 513.267A (gender) 540, 360.600 1 540, 360.600B (sequence) 49, 319.633 2 24, 659.817C (experience) 382, 401.667 1 382, 401.667AB interactions 542.500 2 271.250AC interactions 91.267 1 91.267BC interactions 911.233 2 455.617ABC interactions 19.033 2 9.517Error 41, 186.000 48 858.042Total 1, 014, 831.933 59 c. H0: all (αβγ)ijk equal zero, Ha: not all (αβγ)ijk equal zero. F* = 9.517/858.042 =.01, F(.95; 2, 48) = 3.19. If F* ≤ 3.19 conclude H0, otherwise Ha. Conclude H0. P-value = .99 d. H0: all (αβ)ij equal zero, Ha: not all (αβ)ij equal zero. F* = 271.250/858.042 =.32, F(.95; 2, 48) = 3.19. If F* ≤ 3.19 conclude H0, otherwise Ha. Conclude H0.P -value = .73 H0: all (αγ)ik equal zero, Ha: not all (αγ)ik equal zero. F* = 91.267/858.042 =.11, F(.95; 1, 48) = 4.04. If F* ≤ 4.04 conclude H0, otherwise Ha. Conclude H0.P -value = .75 H0: all (βγ)jk equal zero, Ha: not all (βγ)jk equal zero. F* = 455.617/858.042 =.53, F(.95; 2, 48) = 3.19. If F* ≤ 3.19 conclude H0, otherwise Ha. Conclude H0.P -value = .59 e. H0: all αi equal zero (i = 1, 2), Ha: not all αi equal zero. F* = 540, 360.600/858.042 =629.76, F(.95; 1, 48) = 4.04. If F* ≤ 4.04 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ H0: all βj equal zero (j = 1, 2, 3), Ha: not all βj equal zero. F* = 24, 659.817/858.042 =28.74, F(.95; 2, 48) = 3.19. If F* ≤ 3.19 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ H0: all γk equal zero (k = 1, 2), Ha: not all γk equal zero. F* = 382, 401.667/858.042 =445.67, F(.95; 1, 48) = 4.04. If F* ≤ 4.04 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ f. α ≤ .302 24.14. a. Y1... = 1, 155.933, Y2... = 966.133, Y.1.. = 1, 044.150, Y.2.. = 1, 101.400, Y.3.. = 1, 037.550, Y..1. = 1, 140.867, Y..2. = 981.200 D1 = 189.800, D2 = −57.250, D3 = 6.600, D4 = 63.850, D5 = 159.667, MSE = 858.042, s{D1} = 7.5633, s{Di} = 9.2631 (i = 2, 3, 4), 24-5 s{D5} = 7.5633, B = t(.99; 48) = 2.406 189.800± 2.406(7.5633) 171.603 ≤ D1 ≤ 207.997 −57.250± 2.406(9.2631) −79.537 ≤ D2 ≤ −34.963 6.600± 2.406(9.2631) −15.687 ≤ D3 ≤ 28.887 63.850± 2.406(9.2631) 41.563 ≤ D4 ≤ 86.137 159.667± 2.406(7.5633) 141.470 ≤ D5 ≤ 177.864 b. Y231. = 1, 020.4, s{Y231.} = 13.0999, t(.975; 48) = 2.011, 1, 020.4± 2.011(13.0999), 994.056 ≤ μ231 ≤ 1, 046.744 24.15. a. Yijkm = μ... +α1Xijkm1 + β1Xijkm2 + β2Xijkm3 + γ1Xijkm4 + (αβ)11Xijkm1Xijkm2 + (αβ)12Xijkm1Xijkm3 + (αγ)11Xijkm1Xijkm4 + (βγ)11Xijkm2Xijkm4 + (βγ)21Xijkm3Xijkm4 + (αβγ)111Xijkm1Xijkm2Xijkm4 + (αβγ)121Xijkm1Xijkm3Xijkm4 + εijkm Xijkm1 = {1 if case from level 1 for factor A −1 if case from level 2 for factor A Xijkm2 = {1 if case from level 1 for factor B −1 if case from level 3 for factor B 0 otherwise Xijkm3 = {1 if case from level 2 for factor B −1 if case from level 3 for factor B 0 otherwise Xijkm4 = {1 if case from level 1 for factor C −1 if case from level 2 for factor C b. Yijkm = μ... + α1Xijkm1 + β1Xijkm2 + β2Xijkm3 + γ1Xijkm4 + (αβ)11Xijkm1Xijkm2 + (αβ)12Xijkm1Xijkm3 + (αγ)11Xijkm1Xijkm4 + (βγ)11Xijkm2Xijkm4 + (βγ)21Xijkm3Xijkm4 + εijkm c. Full model: Y = 60.01667− 5.67500X1 − .20000X2 + .10000X3 − 10.28333X4 − .43333X1X2 + 1.09167X1X3 + .15000X1X4 + 2.02500X2X4 − .88333X3X4 − .43333X1X2X4 + .35000X1X3X4 SSE(F) = 49 24-6 Reduced model: Y = 61.15167 − 5.8171X1 − .34167X2 − .32500X3 − 9.66333X4 − .20000X1X2 + 1.04167X1X3 − .47500X1X4 + 1.36667X2X4 − 1.10333X3X4, SSE(R) = 67.8167 H0: all (αβγ)ijk equal zero, Ha: not all (αβγ)ijk equal zero. F* = (67.8167− 49)/2/(49/48) = 9.22, F(.995; 2, 48) = 6.19. If F* ≤ 6.19 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ 24.16. a. Yijkm = μ... +α1Xijkm1 + α2Xijkm2 + β1Xijkm3 + γ1Xijkm4 + (αβ)11Xijkm1Xijkm3 + (αβ)21Xijkm2Xijkm3 + (αγ)11Xijkm1Xijkm4 + (αγ)21Xijkm2Xijkm4 + (βγ)11Xijkm3Xijkm4 + (αβγ)111Xijkm1Xijkm3Xijkm4 + (αβγ)211Xijkm2Xijkm3Xijkm4 + εijkm 24-6 Xijkm1 = {1 if case from level 1 for factor A −1 if case from level 3 for factor A 0 otherwise Xijkm2 = {1 if case from level 2 for factor A −1 if case from level 3 for factor A 0 otherwise Xijkm3 = {1 if case from level 1 for factor B −1 if case from level 2 for factor B Xijkm4 = {1 if case from level 1 for factor C −1 if case from level 2 for factor C b. Yijkm = μ... + α1Xijkm1 + α2Xijkm2 + β1Xijkm3 + γ1Xijkm4 + (αβ)11Xijkm1Xijkm3 + (αβ)21Xijkm2Xijkm3 + (αγ)11Xijkm1Xijkm4 + (αγ)21Xijkm2Xijkm4 + (βγ)11Xijkm3Xijkm4 + εijkm c. Full model: Y = 100.04167 + 10.68333X1 + 9.72083X2 + 7.85833X3 + 4.94167X4 + .28333X1X3 + .15208X2X3 − .17083X1X4 + .24792X2X4 + 3.21667X3X4 − .01667X1X3X4 + .38958X2X3X4 SSE(F) = 266.1375 Reduced model: Y = 100.04167 + 10.68333X1 + 9.72083X2 + 7.85833X3 + 4.94167X4 + .28333X1X3 + .15208X2X3 − .17083X1X4 + .24792X2X4 + 3.21667X3X4 SSE(R) = 270.0804 H0: all (αβγ)ijk equal zero, Ha: not all (αβγ)ijk equal zero. F* = (3.9429/2)/(266.1375/36) = .27, F(.99; 2, 36) = 5.25. If F* ≤ 5.25 conclude H0, otherwise Ha. Conclude H0. P-value = .77 24-7 24.19. ∑ i ∑ j ∑ k ∑ m (Yijkm − Y....)2 = ∑∑∑∑[(Yijk. − Y....) + (Yijkm − Yijk.)]2 = ∑∑∑∑(Yijk. − Y....)2 + ∑∑∑∑(Yijkm − Yijk.)2 + 2∑∑∑∑(Yijk. − Y....)(Yijkm − Yijk.) = n ∑∑∑(Yijk. − Y....)2 + ∑∑∑∑(Yijkm − Yijk.)2 since the cross-product term equals zero 24.20. a. μ.. = 1 abc ∑∑∑ μijk = 1 abc ∑∑∑ (μ... + αi + βj + γk + ...) ... μ ... = μ... + ... = μ... b. ... 24.21. μijk = μ... + αi + βj + γk + (αβ)ij + (αγ)ik + (βγ)jk + (αβγ)ijk ... 24-8 24.22. ... E{MSE} = σ2 ... 24.23. ... 24.24. ... 24-9 ... Chapter 25 RANDOM AND MIXED EFFECTS MODELS 25.3. (1) I, (2) II, (3) I, (4) II 25.5. b. H0: σ2μ = 0, Ha: σ2μ > 0. F* = .45787/.03097 = 14.78, F(.95; 5, 114) = 2.29. If F* ≤ 2.29 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. Y.. = .22767, nT = 120, s{Y..} = .06177, t(.975; 5) = 2.571, .22767± 2.571(.06177), .0689 ≤ μ. ≤ .3865 25.6. a. F(.025; 5, 114) = .1646, F(.975; 5, 114) = 2.680, L = .22583, U = 4.44098 .1842 ≤ σ2μ/σ2 ≤ .8162 b. χ2(.025; 114) = 90.351, χ2(.975; 114) = 145.441, .02427 ≤ σ2 ≤ .03908 c. s2μ = .02135 d.

Satterthwaite: df = (n s2μ)2 / [(MSTR)2/(r− 1) + (MSE)2/(nT − r)] = [20(.02135)]2 / [(.45787)2/5 + (.03097)2/(6·19)] = 4.35, χ2(.025; 4) = .484, χ2(.975; 4) = 11.143 .0083 ≤σ2μ ≤ .1919 e. MLS: c1 = .05, c2 = −.05, MS1 = .45787, MS2 = .03097, df1 = 5, df2 = 114,F1 = F(.975; 5,∞) = 2.57, F2 = F(.975; 114,∞) = 1.28, F3 = F(.975; 5, 114) = 2.68, F4 = F(.975; 114, 5) = 6.02, G1 = .611, G2 = .219 ... HL = .0068, HU = .1740 .0083 ≤σ2μ ≤ .1747 25.7. b. H0: σ2μ = 0, Ha: σ2μ > 0. F* = 5.1483/.1227 = 41.96, F(.95; 3, 16) = 3.24. If F* ≤ 3.24 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. Y.. = 29.79, nT = 20, s{Y..} = .5074, t(.975; 3) = 3.182, 29.79± 3.182(.5074), 28.175 ≤ μ. ≤ 31.405 25.8. a. F(.025; 3, 16) = .0698, F(.975; 3, 16) = 4.080 ... b. χ2(.025; 16) = 6.908, χ2(.975; 16) = 28.845, .0681 ≤ σ2 ≤ .2841 c. s2μ = 1.005 d. Satterthwaite: df = ... χ2(.025; 3) = .216, χ2(.975; 3) = 9.348 ... 25.9. ... Source SS df MSTreatments (Blocks?) ... H0: σ2μ = 0, Ha: σ2μ > 0. F* = ... 25.10. ... 25.11. ... 25.12. ... Source SS df MS ... 25.13. ... Source SS df MS Machines ... 25.14. ... 25.15. ... Source SS df MS Factor A (driver) 280.28475 3 93.42825Factor B (car) 94.71350 4 23.67838AB interactions 2.44650 12 .20388Error 3.51500 20 .17575Total 380.95975 39 H0: σ2αβ = 0, Ha: σ2αβ > 0. F* = .20388/.17575 = 1.16, F(.95; 12, 20) = 2.28. If F* ≤ 2.28 conclude H0, otherwise Ha. Conclude H0. P-value = .37 b. H0: σ2α = 0, Ha: σ2α > 0. F* = 93.42825/.20388 = 458.25, F(.95; 3, 12) = 3.49. If F* ≤ 3.49 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ H0: σ2β = 0, Ha: σ2β > 0. F* = 23.67838/.20388 = 116.14, F(.95; 4, 12) = 3.26. If F* ≤ 3.26 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. s2α = 9.32244, s2β = 2.93434 d. ... 25.16. ... 25.17. ... 25.18. ... 25.19. ... 25.20. ... Source SS df MSBlocks ... 25.21. ... 25.22. ... 25.23. ... 25.24. ... 25.25. ... 25.26. ... 25.27. ... E{MSA} = σ2 + nbσ2α ... E{MSB} ... E{MSAB} = σ2 + nσ2αβ ...

25.28. ... 25.29. ... 25.30. ... 25.31. ... 25.32. ... σ2{Yij} = σ2μ + σ2 ... 25.33. ... Yijk = μ.. + ... 25.34. ... 25.35. ... expectations equal to zero ... 25.36. ... 25.37. ... E{MSE} = σ2 ... 25.38. ... Chapter 26 NESTED DESIGNS,SUBSAMPLING, AND PARTIALLYNESTED DESIGNS 26.4. a. eijk: i = 1 ... b. r = .986 26.5. a. Source SS df MSSchools (A) 1, 695.63 2 847.82Instructors within schools (B(A)) 2, 272.30 3 757.43Error 54.00 6 9.00Total 4, 021.93 11 b. H0: all αi equal zero, Ha: not all αi equal zero. F* = 847.817/9.000 = 94.20, F(.95; 2, 6) = 5.14. If F* ≤ 5.14 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. H0: all βj(i) equal zero, Ha: not all βj(i) equal zero. F* = 757.433/9.000 = 84.16, F(.95; 3, 6) = 4.76. If F* ≤ 4.76 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ d. α ≤ .10 26.6. a. D1 = Y1.. − Y2.. = ... e. ... 26.7. a. eijk: ... 26.8. a. Source SS df MS Machines (A) ... H0: all αi equal zero ... If F* ≤ 3.01 conclude H0, otherwise Ha. Conclude Ha. P-value = 0+ c. H0: all βj(i) equal zero, Ha: not all βj(i) equal zero. F* = 847.817/252.478 = 3.358, F(.90; 2, 9) = 3.01. If F* ≤ 3.01 conclude H0, otherwise Ha. Conclude Ha. P-value = .081 f. See Problem 26a. s{Li} = 5.025 (i = 1, 2, 3), q(.90; 3, 9) = ...

3.32, T = 2.348 −9.75± 2.348(5.025) −21.55 ≤ L1 ≤ 2.05−12.35± 2.348(5.025) −24.15 ≤ L2 ≤ −.55−2.60± 2.348(5.025) −14.40 ≤ L3 ≤ 9.20 g. H0: all σ2{βj(i)} are equal (i = 1, 2, 3), Ha: not all σ2{βj(i)} are equal. Y1 = 62.2, Y2 = 75.5, Y3 = 73.9, MSTR = 11.6433, MSE = 38.0156, F ∗BF = 11.6433/38.0156 = .31, F (.99; 2, 9) = 8.02. If F ∗BF ≤ 8.02 conclude H0, otherwise Ha. Conclude H0. 26.8. a. αi are independent N(0, σ2α); βj(i) are independent N(0, σ2 β); αi, βj(i), and εk(ij) are independent. b. σ2β = 45.7756, σ2 α = 29.7669 c. H0: σ2α = 0, Ha: σ2α > 0. F ∗ = 847.817/252.478 = 3.358, F (.95; 2, 9) = 4.26. If F ∗ ≤ 4.26 conclude H0, otherwise Ha. Conclude H0. P -value = .081 d. c1 = .2, c2 = −.2, MS1 = 252.478, MS2 = 23.600, df1 = 9, df2 = 48, F1 = F (.975; ∞, 9) = 2.11, F2 = F (.975; 48, ∞) = 1.44, F3 = F (.975; ∞, 48) = 1.53, F4 = F (.975; 9, 48) = 2.39, F6 = F (.975; 48, 9) = 3.48, 26.3 G1 = .5261, G2 = .3056, G3 = .01577, G4 = −.1176, HL = 26.766, HU = 117.544, 45.7756− 26.766, 45.7756 + 117.544, 19.01 ≤ σ2β ≤ 163.32 e. Y... = 68.56667, s{Y...} = 3.759, t(.975; 2) = 4.303, 68.56667 ± 4.303(3.759), 52.392 ≤ μ.. ≤ 84.742 26.9. a. eijk: i = 1 j = 1 j = 2 j = 3 j = 4 k = 1 ... 26.10. a. αi are independent N(0, σ2α) ...

[illegible]

.027506 .01833 −.03167 .05583 −.042507 −.00167 −.00167 −.02417 .027508 −.00167 .00833 −.01417 .007509 −.02417 −.00417 .02333 .0050010 −.00417 −.04167 .02333 .0250011 .03333 −.01667 −.03917 .0225012 −.05167 .03833 .02583 −.01250 r = .994 27.26. a.
Source SS df MSSubjects 1.80012 11 .163647Dosage .72615 3 .242050Error .03220 33 .000976Total 2.55847 47 b. H0: all τj equal zero (j = 1, ..., 4), Ha: not all τj equal zero. F ∗ = .242050/.000976 = 248.0, F (.95; 3, 33) = 2.89. If F ∗ ≤ 2.89 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ c. Y.1 = 1.03833, Y.2 = 1.05833, Y.3 = 1.06083, Y.4 = .76917, L1 = Y.1 − Y.2 =−.02000, L2 = Y.2 − Y.3 = −.00250, L3 = Y.3 − Y.4 = .29166, s{Li} = .01275(i = 1, 2, 3), B = t(.983; 33) = 2.22 27-9 −.02000± 2.22(.01275) −.048 ≤ L1 ≤ .008−.00250± 2.22(.01275) −.031 ≤ L2 ≤ .026 .29166± 2.22(.01275) .263 ≤ L3 ≤ .320 d. Yij = μ..
+ ρ1Xij1 + ρ2Xij2 + ρ3Xij3 + ρ4Xij4 + ρ5Xij5 + ρ6Xij6 +ρ7Xij7 + ρ8Xij8 + ρ9Xij9 + ρ10Xij10 + ρ11Xij11 + γ1xij + γ2x2ij + εij Xij1 = 1 if experimental unit from subject 1−1 if experimental unit from subject 12 0 otherwise Xij2, ..., Xij11 are defined similarly xij = −.825 if experimental unit received treatment 1−.325 if experimental unit received treatment 2 .175 if experimental unit received treatment 3 .975 if experimental unit received treatment 4 Y = 1.06647− .24917X1− .26917X2− .23917X3− .12917X4 + .02333X5− .09667X6 −.05667X7+.13333X8+.18583X9+.21583X10+.15833X11−.11341x−.19192x2 e. eij: i j = 1 j = 2 j = 3 j = 41 .02976 −.03389 .02842 −.024292 .00976 −.03389 .01842 .005713 .00976 −.02389 .02842 −.014294 .04976 −.00389 −.00158 −.044295 −.02274 .02361 −.02408 .023216 .02726 −.05639 .07592 −.046797 .00726 −.02639 −.00408 .023218 .00726 −.01639 .00592 .003219 −.01524 −.02889 .04342 .00471 10 .00476 −.06889 .04342 .0207111 .04226 −.04139 −.01908 .0182112 −.04274 .01361 .04592 −.01679 f. H0: γ2 = 0, Ha: γ2 6= 0. SSE(F) = .0456, SSE(R) = .2816, F ∗ = (.2360/1)÷ (.0456/34) = 175.96, F (.99; 1, 34) = 7.44. If F ∗ ≤ 7.44 conclude H0, otherwise Ha. Conclude Ha. 27.27. Note: The subscript for subjects here is l instead of the usual i and the subscriptsfor factors A, B, and C are i, j, and k, respectively.
a. Yijklm = μ.... + αi + βj + γk + ρl(ik) + (αβ)ij + (αγ)ik + (βγ)jk + (αβγ)ijk + εm(ijkl) b. r = .990 27.28. a. 27-10 Source SS df MSA (initial lever press rate) 7.99586 2 3.99793B (dosage level) 25.90210 3 8.63403C (reinforcement schedule) 59.74172 1 59.74172AB interactions .35167 6 .05861AC interactions .09465 2 .04733BC interactions 12.36104 3 4.12035ABC interactions .37040 6 .06173S(AC) (rats, within AC) 1.64179 18 .09121Error .36711 150 .00245Total 108.82634 191 E{MSA} = 64∑ α2i /2 + 8σ2 ρ + σ2 E{MSB} = 48∑ β2j /3 + σ2 E{MSC} = 96∑ γ2k/1 + 8σ2 ρ + σ2 E{MSS(AC)} = 8σ2ρ + σ2 E{MSAB} = 16∑ ∑ (αβ)2ij/6 + σ2 E{MSAC} = 32∑ ∑ (αγ)2ik/2 + 8σ2 ρ + σ2 E{MSBC} = 24∑ ∑ (βγ)2jk/3 + σ2 E{MSABC} = 8∑ ∑ ∑ (αβγ)2ijk/6 + σ2 E{MSE} = σ2 b. H0: all (αβγ)ijk equal zero, Ha: not all (αβγ)ijk equal zero. F ∗ = .06173/.00245 = 25.196, F (.99; 6, 150) = 2.92.
If F ∗ ≤ 2.92 conclude H0, otherwise Ha. Conclude Ha. P -value = 0+ c. Yijk..: k i j = 1 j = 2 j = 3 j = 41 1 .81375 .82375 .83625 .53500 2 1.05375 1.06625 1.05625 .773753 1.25500 1.25625 1.27125 1.00750 2 1 2.15125 2.33625 1.88750 .881252 2.59250 2.58375 2.21875 1.012503 3.04750 2.75125 2.38125 1.29250 27.29. a.
F ∗R P (F ∗R) F ∗R 0 12/216.25 90/216 1.00 36/2161.60 36/2167.00 36/216 Undefined 6/216 b. F (.90; 2, 4) = 4.32, P (F ∗R ≥ 7.00) = .972, P (F ∗R ≤ 1.60) = .806 27-11 27-12 Chapter 28 BALANCED INCOMPLETEBLOCK, LATIN SQUARE, ANDRELATED DESIGNS 28.3. One such design, for which nb = 3, n = 2, and np = 1: 21 32 3 28.4. For r = 7, rb = 5, a BIBD exists for nb =7! 5!(7− 5)!= 21. Since nbrb = nr, n = 21(5)/7 = 15. Since np(r − 1) = n(rb − 1), np = 15(5− 1)/(7− 1) = 10. 28.5. For r = 8, rb = 3, a BIBD exists for nb =8! 3!(8− 3)!= 56. Since nbrb = nr, n = 56(3)/8 = 21. Since np(r − 1) = n(rb − 1), np = 21(3− 1)/(8− 1) = 6. 28.6. eij: i j = 1 j = 2 j = 3 j = 4 j = 5 j = 6 j = 7 j = 8 j = 91 −.704 .185 .5192 .222 −.111 −.1113 .556 −1.000 .4444 −.481 −.259 .7415 −.926 .296 .6306 −.519 .481 .0377 .815 .259 −1.0748 .222 .444 −.6679 −.111 .667 −.556 10 −.222 .444 −.22211 1.444 −.667 −.77812 .370 .926 −1.296 28-1 r = .990 28.7. a. μ.. = 19.36, τ 1 = .33, τ 2 = −2.22, τ 3 = −6.00, τ 4 = −12.89, τ 5 = 6.11, τ 6 = 3.56,τ 7 1.22, τ 8 = −.22, τ 9 = 10.11. μ.1 = 19.69, μ.2 = 17.14, μ.3 = 13.36, μ.4 = 6.47, μ.5 = 25.47, μ.6 = 22.92,μ.7 = 20.58, μ.8 = 19.14, μ.9 = 29.47. b. H0: all τj equal zero (j = 1, 2, . . . , 8), Ha: not all τj equal zero. SSE(F) = 14.519,SSE(R) = 1097.33, F ∗ = (1082.811/8) ÷ (14.519/16) = 149.2, F (.95; 8, 16) =2.59. If F ∗ ≤ 2.59 conclude H0 otherwise Ha.
Conclude Ha. P -value = 0+ c. H0: all ρi equal zero (j = 1, 2, . . . , 11), Ha: not all ρi equal zero. SSE(F) = 14.519,SSE(R) = 25.25, F ∗ = (10.731/11) ÷ (14.519/16) = 1.08, F (.95; 11, 16) = 2.46.If F ∗ ≤ 2.46 conclude H0, otherwise Ha. Conclude H0. P -value = .43 d. μ.5 = 25.47, s2(μ.5) = s2(μ..) + s2(τ5) = (.02778 + .29630).907 = .2939, B =t(.975; 16) = 2.120, 25.47± 2.120(.542), 24.32 ≤ μ.5 ≤ 26.62 e. 28-2 95% C.I. lower center upperμ.1 − μ.2 −.21 2.56 5.32μ.1 − μ.3 3.57 6.33 9.10μ.1 − μ.4 10.46 13.22 15.99μ.1 − μ.5 −8.54 −5.78 −3.01μ.1 − μ.6 −5.99 −3.22 −.46μ.1 − μ.7 −3.66 −.89 1.88μ.1 − μ.8 −2.21 .56 3.32μ.1 − μ.9 −12.54 −9.78 −7.01μ.2 − μ.3 1.01 3.78 6.54μ.2 − μ.4 7.90 10.67 13.43μ.2 − μ.5 −11.10 −8.33 −5.57μ.2 − μ.6 −8.54 −5.78 −3.01μ.2 − μ.7 −6.21 −3.44 −.68μ.2 − μ.8 −4.77 −2.00 .77μ.2 − μ.9 −15.10 −12.33 −9.57μ.3 − μ.4 4.12 6.89 9.66μ.3 − μ.5 −14.88 −12.11 −9.35μ.3 − μ.6 −12.32 −9.56 −6.79μ.3 − μ.7 −9.99 −7.22 −4.46μ.3 − μ.8 −8.54 −5.78 −3.01μ.3 − μ.9 −18.88 −16.11 −13.35μ.4 − μ.5 −21.77 −19.00 −16.23μ.4 − μ.6 −19.21 −16.44 −13.68μ.4 − μ.7 −16.88 −14.11 −11.35μ.4 − μ.8 −15.43 −12.67 −9.90μ.4 − μ.9 −25.77 −23.00 −20.23μ.5 − μ.6 −.21 2.56 5.32μ.5 − μ.7 2.12 4.89 7.66μ.5 − μ.8 3.57 6.33 9.10μ.5 − μ.9 −6.77 −4.00 −1.23μ.6 − μ.7 −.43 2.33 5.10μ.6 − μ.8 1.01 3.78 6.54μ.6 − μ.9 −9.32 −6.56 −3.79μ.7 − μ.8 −1.32 1.44 4.21μ.7 − μ.9 −11.66 −8.89 −6.12μ.8 − μ.9 −13.10 −10.33 −7.57 28.8. a. eij: i j = 1 j = 2 j = 3 j = 41 13.2083 8.8333 −22.04172 −7.9167 4.7083 3.20833 −5.2917 −1.5417 6.83334 −13.5417 23.5833 −10.0417 r = .995 28-3 28.9. a. μ.. = 297.667, τ 1 = −45.375, τ 2 = −41.000, τ 3 = 30.875, τ 4 = 55.500 μ.1 = 252.292, μ.2 = 256.667, μ.3 = 328.542, μ.4 = 353.167 b. H0: τ1 = τ2 = τ3 = 0, Ha: not all τj equal zero. SSE(F) = 1750.9, SSE(R) =22480, F ∗ = (20729.1/3) ÷ (1750.9/5) = 19.73, F (.95; 3, 5) = 5.41. If F ∗ ≤ 5.41conclude H0, otherwise Ha. Conclude Ha. P -value = .003 c. H0: ρ1 = ρ2 = ρ3 = 0, Ha: not all ρi equal zero. SSE(F) = 14.519, SSE(R) =22789, F ∗ = (21038.1/3) ÷ (1750.9/5) = 20.03, F (.95; 3, 5) = 5.41. If F ∗ ≤ 5.41conclude H0, otherwise Ha. Conclude Ha. P -value = .003 d.
μ.1 = 252.292, s2(μ.1) = s2(μ..) + s2(τ1) = (.08333 + .28125)350.2 = 127.68,B = t(.975; 5) = 2.571, 252.292± 2.571(11.30), 223.240 ≤ μ.1 ≤ 281.344 e.95% C.I. lower center upperμ.1 − μ.2 −64.19 −4.375 55.44μ.1 − μ.3 −136.07 −76.250 −16.43μ.1 − μ.4 −160.69 −100.875 −41.06μ.2 − μ.3 −131.70 −71.87 −12.06μ.2 − μ.4 −156.30 −96.50 −36.68μ.3 − μ.4 −84.44 −24.63 35.19 28.10. r = 4, and rb = 3, dfe = 4n− 4− 4n/3 + 1 = 8n/3− 3. Since np = n(3− 1)/(4− 1) = 2n/3, σ2{Dj} = 2σ2(3)/(4np) = 9σ2/(4n) Tσ{Dj} =1√2q[.95; 4, 8n/3− 3] √9σ2 4n For σ2 = 2.0 and Tσ{Dj} ≤ 1.5, so we need to iterate to find n so that n ≥ q2[.95; 4, 8n/3− 3] We iteratively find n ≥ 15. Since design 2 in Table 28.1 has n = 3, we requirethat design 2 be repeated 5 times. Thus, n = 15, and nb = 20. 28.11. r = 5, and rb = 4, dfe = 5n− 5− 5n/4 + 1 = 15n/4− 4.
Since np = n(4− 1)/(5− 1) = 3n/4, σ2{Dj} = 2σ2(4)/(5np) = 32σ2/(15n) Tσ{Dj} =1√2q[.90; 5, 15n/4− 4] √32σ2 15n For σ2 = 1.5 and Tσ{Dj} ≤ 1.25, so we need to iterate to find n so that n ≥ 1.024q2[.90; 5, 15n/4− 4] We iteratively find n ≥ 14. Since design 5 in Table 28.1 has n = 4, we requirethat design 2 be repeated 4 times. Thus, n = 16, and nb = 20. 28.14. eijk: i j = 1 j = 2 j = 3 j = 41 −.1375 .0875 −.0125 .06252 −.0125 −.0125 .1625 −.13753 .1375 −.0875 −.0625 .01254 .0125 .0125 −.0875 .0625 28-4 r = .986 28.15. a.
Y..1 = 1.725, Y..2 = 1.900, Y..3 = 2.175, Y..4 = 2.425 b. Source SS df MSRows (sales volumes) 5.98187 3 1.99396Columns (locations) .12188 3 .04062Treatments (prices) 1.13688 3 .37896Error .11875 6 .01979Total 7.35938 15 H0: all τk equal zero (k = 1, ..., 4), Ha: not all τk equal zero. F ∗ = .37896/.01979 =19.149, F (.95; 3, 6) = 4.76. If F ∗ ≤ 4.76 conclude H0, otherwise Ha. ConcludeHa. P -value = .002 c. L1 = Y..1 − Y..2 = −.175, L2 = Y..1 − Y..3 = −.450, L3 = Y..1 − Y..4 = −.700,L4 = Y..2 − Y..3 = −.275, L5 = Y..2 − Y..4 = −.525, L6 = Y..3 − Y..4 = −.250,s{Li} = .09947 (i = 1, ..., 6), q(.90; 4, 6) = 4.07, T = 2.8779 −.175± 2.8779(.09947) −.461 ≤ L1 ≤ .111−.450± 2.8779(.09947) −.736 ≤ L2 ≤ −.164−.700± 2.8779(.09947) −.986 ≤ L3 ≤ −.414−.275± 2.8779(.09947) −.561 ≤ L4 ≤ .011−.525± 2.8779(.09947) −.811 ≤ L5 ≤ −.239−.250± 2.8779(.09947) −.536 ≤ L6 ≤ .036 28.16. a. E1 = 21.1617, E2 = 1.2631, E3 = 25.9390 28.17. eijk: i j = 1 j = 2 j = 3 j = 4 j = 51 −.88 −.68 .92 .32 .322 .32 .12 −.28 .92 −1.083 .52 −.68 −1.08 .12 1.124 −.68 1.92 .52 −.08 −1.685 .72 −.68 −.08 −1.28 1.32 r = .993 28.18. a. Y..1 = 7.0, Y..2 = 7.4, Y..3 = 15.0, Y..4 = 19.0, Y..5 = 13.4 b. Source SS df MSRows (executives) 220.16 4 55.040Columns (months) 10.96 4 2.740Treatments (reports) 527.36 4 131.840Error 19.28 12 1.607Total 777.76 24 H0: all τk equal zero (k = 1, ..., 5), Ha: not all τk equal zero. F ∗ = 131.840/1.607 =82.04, F (.99; 4, 12) = 5.41. If F ∗ ≤ 5.41 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ 28-5 c. L1 = Y..1 − Y..2 = −.4, L2 = Y..1 − Y..3 = −8.0, L3 = Y..1 − Y..4 = −12.0,L4 = Y..1 − Y..5 = −6.4, L5 = Y..2 − Y..3 = −7.6, L6 = Y..2 − Y..4 = −11.6,L7 = Y..2 − Y..5 = −6.0, L8 = Y..3 − Y..4 = −4.0, L9 = Y..3 − Y..5 = 1.6, L10 =Y..4 − Y..5 = 5.6, s{Li} = .8017 (i = 1, ..., 10), q(.95; 5, 12) = 4.51, T = 3.189 −.4± 3.189(.8017) −2.96 ≤ L1 ≤ 2.16−8.0± 3.189(.8017) −10.56 ≤ L2 ≤ −5.44−12.0± 3.189(.8017) −14.56 ≤ L3 ≤ −9.44−6.4± 3.189(.8017) −8.96 ≤ L4 ≤ −3.84−7.6± 3.189(.8017) −10.16 ≤ L5 ≤ −5.04−11.6± 3.189(.8017) −14.16 ≤ L6 ≤ −9.04−6.0± 3.189(.8017) −8.56 ≤ L7 ≤ −3.44−4.0± 3.189(.8017) −6.56 ≤ L8 ≤ −1.44 1.6± 3.189(.8017) −.96 ≤ L9 ≤ 4.165.6± 3.189(.8017) 3.04 ≤ L10 ≤ 8.16 28.19. a. E1 = 6.66, E2 = 1.14, E3 = 7.65 28.20. φ = 3.399, 1− β ∼= .99 28.21. φ = 2.202, 1− β ∼= .69 28.22. eijkl: i j = 1 j = 2 j = 3 j = 41 .01625 −.01875 .01625 −.013752 .00625 .01875 −.05375 .028753 −.00875 −.03125 .03375 .006254 −.01375 .03125 .00375 −.02125 r = .980 28.23. a. Yijkl = μ.... + ρi + κj + αk + βl + (αβ)kl + ε(ijkl) b. Source SS df MSRows (subjects) .03462 3 .01154Columns (periods) .00592 3 .00197Treatments .43333 3 .14444X .22801 1 .22801Y .19581 1 .19581XY interactions .00951 1 .00951Error .00904 6 .00151Total .48291 15 H0: all (αβ)kl equal zero, Ha: not all (αβ)kl equal zero. F ∗ = .00951/.00151 =6.298, F (.90; 1, 6) = 3.78. If F ∗ ≤ 3.78 conclude H0, otherwise Ha. Conclude Ha.P -value = .046 c. Y..1 = .0050, Y..2 = .1950, Y..3 = .1775, Y..4 = .4650, L = −.0975, s{L} = .03886,t(.95; 6) = 1.943, −.0975± 1.943(.03886),−.1730 ≤ L ≤ −.0220 28-6 28.24.
a. Yijk = μ... + ρ1Xijk1 + ρ2Xijk2 + ρ3Xijk3 + κ1Xijk4 + κ2Xijk5 +κ3Xijk6 + τ1Xijk7 + τ2Xijk8 + τ3Xijk9 + ε(ijk) Xijk1 = 1 if experimental unit from row blocking class 1−1 if experimental unit from row blocking class 4 0 otherwise Xijk2 and Xijk3 are defined similarly Xijk4 = 1 if experimental unit from column blocking class 1−1 if experimental unit from column blocking class 4 0 otherwise Xijk5 and Xijk6 are defined similarly Xijk7 = 1 if experimental unit received treatment 1−1 if experimental unit received treatment 4 0 otherwise Xijk8 and Xijk9 are defined similarly b. Full model: Y = 2.05625− .70625X1 − .45625X2 + .34375X3 + .14375X4 − .05625X5 − .00625X6 − .33125X7 − .15625X8 + .11875X9 SSE(F) = .1188 Reduced model: Y = 2.05625− .70625X1− .45625X2 + .34375X3 + .14375X4− .05625X5− .00625X6 SSE(R) = 1.2556 H0: all τk equal zero (k = 1, 2, 3), Ha: not all τk equal zero. F ∗ = (1.1368/3) ÷(.1188/6) = 19.138, F (.95; 3, 6) = 4.76. If F ∗ ≤ 4.76 conclude H0, otherwise Ha.Conclude Ha. c.
L = τ 3 − (−τ 1 − τ 2 − τ 3) = 2τ 3 + τ 1 + τ 2 = −.250, s2{τ i} = .00371 (i = 1, 2, 3),s{τ 1, τ 2} = s{τ 1, τ 3} = s{τ 2, τ 3} = −.00124, s{L} = .09930, t(.975; 6) = 2.447,−.250± 2.447(.09930), −.493 ≤ L ≤ −.007 d. (i) Full model: Y = 2.02917− .67917X1 − .53750X2 + .37083X3 + .17083X4 − .02917X5 − .08750X6 − .30417X7 − .23750X8 + .14583X9 SSE(F) = .0483 Reduced model: Y = 2.05556− .70556X1− .45833X2 + .34444X3 + .14444X4− .05556X5− .00833X6 SSE(R) = 1.2556 H0: all τk equal zero (k = 1, 2, 3), Ha: not all τk equal zero. F ∗ = (1.2073/3) ÷(.0483/5) = 41.66, F (.95; 3, 5) = 5.41.
If F ∗ ≤ 5.41 conclude H0, otherwise Ha.Conclude Ha. 28-7 (ii) L = τ 1 − τ 2 = −.06667, s2{τ 1} = .00191, s2{τ 2} = .00272, s{τ 1, τ 2} =−.00091, s{L} = .0803, t(.975; 5) = 2.571, −.06667± 2.571(.0803), −.273 ≤ L ≤.140 28.25. a.
Full model: Y = 12.54286 + 1.91429X1 − 3.54286X2 + 3.25714X3 − 3.28571X4 + 1.11429X5 −.34286X6 − .94286X7 − .74286X8 − 5.54286X9 −5.14286X10 + 3.11329X11 + 6.71429X12 SSE(F) = 12.6286 Reduced model: Y = 11.96471 + .44706X1 − 2.96471X2 + 3.83529X3 − 3.55294X4 − .35294X5 +.23529X6 − .36471X7 − .16471X8 SSE(R) = 494.2353 H0: all τk equal zero (k = 1, ..., 4), Ha: not all τk equal zero. F ∗ = (481.6067/4)÷(12.6286/10) = 95.340, F (.99; 4, 10) = 5.99. If F ∗ ≤ 5.99 conclude H0, otherwiseHa. Conclude Ha. b. L = τ 4 − τ 1 = 12.25715, s2{τ 1} = .20927, s2{τ 4} = .28144, s{τ 1, τ 4} = −.06134,s{L} = .7832, t(.995; 10) = 3.169, 12.25715± 3.169(.7832), 9.775 ≤ L ≤ 14.739 28.26. eijkm: i m j = 1 j = 2 j = 3 j = 41 1 −1.9375 −1.5625 .6875 1.3125 2 1.0625 3.4375 −2.3125 −.68752 1 −3.6875 6.0625 −1.1875 3.8125 2 2.3125 .0625 −5.1875 −2.18753 1 −4.0625 1.1875 −.6875 4.0625 2 2.9375 −4.8125 4.3125 −2.93754 1 −.3125 .3125 .1875 −2.6875 2 3.6875 −4.6875 4.1875 −.6875 r = .990 28.27. a.
Yijklm = μ.... + ρi + κj + αk + βl + (αβ)kl + εm(ijkl) b. Source SS df MSRows (ages) 658.09375 3 219.36458Columns (education levels) 18.34375 3 6.11458Treatments 1, 251.34375 3 417.11458Volumes 399.03125 1 399.03125Products 850.78125 1 850.78125Volume-product interactions 1.53125 1 1.53125 Error 285.43750 22 12.97443Total 2, 213.21875 31 28-8 H0: all (αβ)kl equal zero, Ha: not all (αβ)kl equal zero. F ∗ = 1.53125/12.97443 =.118, F (.99; 1, 22) = 7.95. If F ∗ ≤ 7.95 conclude H0, otherwise Ha. Conclude H0.P -value = .73 c. H0: α1 = α2 = 0, Ha: not both α1 and α2 equal zero. F ∗ = 399.03125/12.97443 =30.755, F (.99; 1, 22) = 7.95.
If F ∗ ≤ 7.95 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ H0: β1 = β2 = 0, Ha: not both β1 and β2 equal zero. F ∗ = 850.78125/12.97443 =65.574, F (.99; 1, 22) = 7.95. If F ∗ ≤ 7.95 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ d. Y..1. = 61.750, Y..2.
= 69.250, Y..3. = 72.500, Y..4.
= 79.125, L1 =μ..1 + μ..3 2− μ..2 + μ..4 2 L2 =μ..1 + μ..2 2− μ..3 + μ..4 2 L1 = −7.0625, L2 = −10.3125, s{L1} = s{L2} = 1.2735, B = t(.9875; 22) = 2.4055 −7.0625± 2.4055(1.2735) −10.126 ≤ L1 ≤ −3.999−10.3125± 2.4055(1.2735) −13.376 ≤ L2 ≤ −7.249 28.28. eijkm: j = 1 j = 2 j = 3m = 1 4.3704 −2.7407 −1.6296 i = 1 m = 2 −3.6296 1.2593 2.3704m = 3 −2.2963 3.5926 −1.2963m = 1 −.9630 −1.1852 2.1481 i = 2 m = 2 1.0370 −1.1852 .1481m = 3 2.0370 1.8148 −3.8519m = 1 −3.5185 −.8519 4.3704 i = 3 m = 2 .1481 3.8148 −3.9630m = 3 2.8148 −4.5185 1.7037 r = .986 28.29. a. Source SS df MSPatterns 14.2963 2 7.1481Order positions 1, 803.6296 2 901.8148Questionnaires 3, 472.0741 2 1, 736.0370Subjects (within patterns) 159.5556 6 26.5926Error 194.9630 14 13.9259Total 5, 644.5185 26 H0: all ρi equal zero (i = 1, 2, 3), Ha: not all ρi equal zero. F ∗ = 7.1481/26.5926 =.269, F (.95; 2, 6) = 5.14. If F ∗ ≤ 5.14 conclude H0, otherwise Ha. Conclude H0.P -value = .77 28-9 H0: all κj equal zero (j = 1, 2, 3), Ha: not all κj equal zero.
F ∗ = 901.8148/13.9259 =64.758, F (.95; 2, 14) = 3.74. If F ∗ ≤ 3.74 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ H0: all τk equal zero (k = 1, 2, 3), Ha: not all τk equal zero. F ∗ = 1, 736.0370/13.9259 =126.66, F (.95; 2, 14) = 3.74. If F ∗ ≤ 3.74 conclude H0, otherwise Ha. ConcludeHa. P -value = 0+ b. Y..1. = 22.3333, Y..2. = 22.4444, Y..3. = 46.4444, L1 = Y..1. − Y..2. = −.1111,L2 = Y..1. − Y..3. = −24.1111, L3 = Y..2. − Y..3. = −24.0000, s{Li} = 1.75916(i = 1, 2, 3), q(.90; 3, 14) = 3.16, T = 2.234 −.1111± 2.234(1.75916) −4.0411 ≤ μ..1 − μ..2 ≤ 3.8189−24.1111± 2.234(1.75916) −28.0411 ≤ μ..1 − μ..3 ≤ −20.1811−24.0000± 2.234(1.75916) −27.9300 ≤ μ..2 − μ..3 ≤ −20.0700 28-10 Chapter 29 EXPLORATORY EXPERIMENTS –TWO-LEVEL FACTORIAL ANDFRACTIONAL FACTORIALDESIGNS 29.1. Yi = β0Xi0 + β1Xil + β2Xi2 + β3Xi3 + β4Xi4 + β12Xi12 + β13Xi13 +β14Xi14 + β23Xi23 + β24Xi24 + β34Xi34 + β123Xi123 +β124Xi124 + β134Xi134 + β234Xi234 + β1234Xi1234 + εi 6, 4, 1 29.2. Fractional factorial designs can be used. 29.3. a. Six factors, two levels, 64 trials b. No 29.4. a. Seven factors, two levels, 8 trials; no b. Yes, no 29.5. X0 X1 X2 X3 X12 X13 X23 X123 1 −1 −1 −1 1 1 1 −11 1 −1 −1 −1 −1 1 1 11 −1 1 −1 −1 1 −1 11 1 1 −1 1 −1 −1 −11 −1 −1 1 1 −1 −1 11 1 −1 1 −1 1 −1 −11 −1 1 1 −1 −1 1 −11 1 1 1 1 1 1 1 29-1 X′X = 8 0 0 0 0 0 0 00 8 0 0 0 0 0 00 0 8 0 0 0 0 00 0 0 8 0 0 0 00 0 0 0 8 0 0 00 0 0 0 0 8 0 00 0 0 0 0 0 8 00 0 0 0 0 0 0 8 = 8I = nT I 29.6. a. σ2{b1} = σ2/nT = 52/64 = .391. Yes, yes b. z(.975) = 1.96, nT = [1.96(5)/(.5)]2 = 384.16, 384.16/64 = 6 replicates 29.7. a. Yi = β0Xi0 + β1Xi1 + · · ·+ β5Xi5 + β12Xi12 + · · ·+ β45Xi45 + β123Xi123 + · · ·+β345Xi345 + β1234Xi1234 + · · ·+ β2345Xi2345 + β12345Xi12345 + εi Coef. bq b0 6.853b1 1.606b2 −.099b3 1.258b4 −1.151b5 −1.338b12 −.033b13 .455 Coef. bq b14 −.239b15 .611b23 −.134b24 −.127b25 −.045b34 −.311b35 .912b45 −.198 Coef. bq b123 .070b124 .020b125 −.118b134 −.378b135 −.138b145 −.183b234 .233b235 .055 Coef. bq b245 .076b345 −.576b1234 .062b1235 .323b1245 .357b1345 −.122b2345 −.292b12345 .043 29.8. a. Yi = β0Xi0 + β1Xi1 + · · ·+ β5Xi5 + β12Xi12 + · · ·+ β45Xi45 + εi Coef. bq P -valueb0 6.853b1 1.606 .000b2 −.099 .689b3 1.258 .000b4 −1.151 .000b5 −1.338 .000b12 −.033 .892b13 .455 .080 Coef. bq P -valueb14 −.239 .340b15 .611 .023b23 −.134 .589b24 −.127 .610b25 −.045 .855b34 −.311 .219b35 .912 .002b45 −.198 .426 b. H0: Normal, Ha: not normal. r = .983. If r ≥ .9656 conclude H0, otherwise Ha.Conclude H0. c. H0: βq = 0, Ha: βq 6= 0. s{bq} = .2432. If P -value ≥ .0034 conclude H0, otherwiseHa. Active effects (see part a): β1, β3, β4, β5, β35 29.9. a. Yi = β0 + β1Xi1 + · · ·+ β4Xi4 + β12Xi12 + · · ·+ β34Xi34 + β123Xi123 + · · ·+β234Xi234 + β1234Xi1234 + εi 29-2 Coef. bq P -valueb0 3.7784b1 −.3113 .020b2 −.0062 .903b3 −.1463 .083b4 .0837 .204b12 .0050 .922b13 .0400 .468b14 .0025 .961 Coef. bq P -valueb23 −.0925 .176b24 .0125 .807b34 −.2175 .040b123 −.0087 .865b124 .0538 .354b134 −.0363 .505b234 −.0138 .788b1234 .0050 .922 (Note: P -values based on MSPE; see part d.) d. H0: βq = 0, Ha: βq 6= 0. MSPE = .0324, s{bq} =√ .0324/16 = .0450. If P -value ≥ .05 conclude H0, otherwise Ha. Active effects (see part a): β1, β34 29.10. a. Coef. bq P -valueb0 3.778b1 −.3112 .000b3 −.1462 .006b4 .0838 .084b34 −.2175 .000 b. H0: Normal, Ha: not normal. r = .970. If r ≥ .9485 conclude H0, otherwise Ha.Conclude H0. c. H0: βq = 0, Ha: βq 6= 0. s{bq} = .0449. If P -value ≥ .01 conclude H0, otherwiseHa. Active effects (see part a): β1, β3, β34. d. H0: No lack of fit, Ha: lack of fit. SSLF = SSE − SSPE = .45248 − .25617 =.19631. F ∗ = [.19631/4] ÷ (.25617/10) = 1.92, F (.95; 4, 10) = 3.48.
If F ∗ ≤ 3.48conclude H0, otherwise Ha. Conclude H0. e. Set X1, X3, X4 at high levels to minimize failure rate. 29.11. a. 0 = −234, resolution = III b. 0 = −234, 1 = −1234, 2 = −34, 3 = −24, 4 = −23, 12 = −134, 13 = −124, 14 = −123 29.12. a. X1 X2 X3 X4 −1 −1 −11 −1 −1 1 −1 1 11 −1 −1 −1 −1 1 11 −1 1 −1 −1 1 1 1 −11 1 1 1
Resolution = IV 29-3 b. For example, dropping X1 and arranging in standard order: X2 X3 X4 −1 −1 −11 −1 −1 −1 1 −11 1 −1 −1 −1 11 −1 1 −1 1 11 1 1 29.13. No 29.14.X1 X2 X3 X4 1 −1 −1 −1 −1 1 −1 −1 −1 1 −1 −1 1 1 1 1 −11 −1 1 −1 1 1 −1 1 1 1 −1 −1 1 1 1 1 1 1 Yes; use 0 = 1234 for resolution IV. 29.15. Defining relation: 0 = 123 = 245 = 1345 Confounding scheme: 0 = 123 = 245 = 13451 = 23 = 1245 = 3452 = 13 = 45 = 123453 = 12 = 2345 = 1454 = 1234 = 25 = 1355 = 1235 = 24 = 13414 = 234 = 125 = 3515 = 235 = 124 = 34 Resolution = III, no 29.16. Defining relation: 0 = −145 = −234 = 1235 Confounding scheme: 0 = −145 = −234 = 12351 = −45 = −1234 = 2352 = −1245 = −34 = 1353 = −1345 = −24 = 1254 = −15 = −23 = 123455 = −14 = −2345 = 12312 = −245 = −134 = 3513 = −345 = −124 = 25 29-4 No 29.17. Defining relation: 0 = 124 = 135 = 2345 = 236 = 1346 = 1256 = 456 X1 X2 X3 X4 X5 X6 −1 −1 −1 1 1 11 −1 −1 −1 −1 1 −1 1 −1 −1 1 −1 −1 11 1 −1 1 −1 −1 −1 −1 1 1 1 −1 −11 −1 1 −1 1 −1 −1 1 1 −1 −1 11 1 1 1 1 1 Resolution = III 29.18. a. Defining relation: 0 = 1235 = 2346 = 1247 = 1456 = 3457 = 1367 = 2567, resolution = IV, no b. Omitting four-factor and higher-order interactions: 1 = 235 = 247 = 367 = 4562 = 135 = 147 = 346 = 5673 = 125 = 167 = 246 = 4574 = 127 = 156 = 236 = 3575 = 123 = 146 = 267 = 3476 = 137 = 145 = 234 = 2577 = 124 = 136 = 256 = 34512 = 35 = 4713 = 25 = 6714 = 27 = 5615 = 23 = 4616 = 37 = 4517 = 24 = 3626 = 34 = 57 c. Yi = β0Xi0 + β1Xi1 + · · ·+ β7Xi7 + β12Xi12 + β13Xi13 + β14Xi14 +β15Xi15 + β16Xi16 + β17Xi17 + β26Xi26 + εi Coef. bq b0 8.028b1 .127b2 .003b3 .021b4 −2.077 Coef. bq b5 .724b6 −.467b7 −.766b12 .354b13 −.066 Coef.
bq b14 −.316b15 .318b16 .117b17 .021b26 −.182 e. H0: β12 = · · · = β17 = β26 = 0, Ha: not all βq = 0. F ∗ = (6.046/7)÷ (.1958/1) =4.41, F (.99; 7, 1) = 5, 928. If F ∗ ≤ 5, 928 conclude H0, otherwise Ha. ConcludeH0. 29.19. a.
29-5 Coef. bq P -valueb0 8.028b1 .127 .581b2 .003 .989b3 .021 .928 Coef. bq P -valueb4 −2.077 .000b5 .724 .011b6 −.467 .067b7 −.766 .008 b. H0: Case i not an outlier, Ha: case i an outlier (i = 3, 14). t3 = 2.70, t14 = −4.09,t(.99844; 7) = 4.41. If | ti |≤ 4.41 conclude H0, otherwise Ha. Conclude H0 forboth cases. c. H0: Normal, Ha: not normal. r = .938.
If r ≥ .929 conclude H0, otherwise Ha.Conclude H0.
d. H0: βq = 0, Ha: βq 6= 0. s{bq} = .2208.
If P -value ≥ .02 conclude H0, otherwiseHa. Active effects (see part a): β4, β5, β7 e.
Set X4 = −1, X5 = 1, X7 = −1 to maximize extraction. 29.20. a. Yi = β0Xi0 + β1Xi1 + · · ·+ β9Xi9 + εi Coef. bq P -valueb0 70.11b1 13.52 .060b2 −.99 .870b3 1.32 .829b4 2.36 .701 Coef. bq P -valueb5 13.49 .060b6 .12 .984b7 −21.58 .010b8 −4.07 .512b9 3.07 .618 d. H0: βq = 0, Ha: βq 6= 0. s{bq} = 5.841. If P -value ≥ .10 conclude H0, otherwiseHa. Active effects (see part a): β1, β5, β7.
29.21.
a. b0 = 70.11, b1 = 13.52, b5 = 13.49, b7 = −21.58 b. H0: Normal, Ha: not normal. r = .951. If r ≥ .941 conclude H0, otherwise Ha.Conclude H0. c. H0: No lack of fit, Ha: lack of fit. SSLF = SSE−SSPE = 3, 824−1, 068 = 2, 756,F ∗ = (2, 756/4) ÷ (1, 068/8) = 5.16, F (.95; 4, 8) = 3.84. If F ∗ ≤ 3.84 concludeH0, otherwise Ha. Conclude Ha. 29.22. a. Yi = β0Xi0 + β1Xi1 + β5Xi5 + β7Xi7 + β15Xi15 + β17Xi17 +β57Xi57 + β157Xi157 + εi Coef. bq P -valueb0 70.11b1 13.52 .000b5 13.49 .000b7 −21.58 .000 Coef.
bq P -valueb15 11.68 .004b17 −1.32 .660b57 5.83 .078b157 .12 .968 H0: βq = 0, Ha: βq 6= 0. s{bq} = 2.889. If P -value ≥ .01 conclude H0, otherwiseHa. Active effects: β1, β5, β7, β15 29.23.
a. Defining relation: 0 = 134 Confounding scheme: 29-6 0 = 1341 = 342 = 12343 = 14 4 = 1312 = 23423 = 12424 = 123 Yes. Defining relation 0 = 1234 would yield a resolution IV design. b. Yi = β0Xi0 + β1Xi1 + β2Xi2 + β3Xi3 + β4Xi4 + β12Xi12 +β23Xi23 + β24Xi24 + εi Coef. bq b0 747.50b1 −207.25b2 −17.00b3 108.00 Coef. bq b4 88.25b12 −24.75b23 −29.00b24 −18.75 29.24. a.
Coef. bq P -valueb0 747.50b1 −207.25 .003b2 −17.00 .538b3 108.00 .022b4 88.25 .037 H0: βq = 0, Ha: βq 6= 0. s{bq} = 24.53. If P -value ≥ .05 conclude H0, otherwiseHa. Active effects: β1, β3, β4 b. Set X1 = −1, X3 = 1, X4 = 1 to maximize defect-free moldings. 29.25. Confounding scheme for design: 0 = 124 = 135 = 23451 = 24 = 35 = 123452 = 14 = 1235 = 3453 = 1234 = 15 = 2454 = 12 = 1345 = 2355 = 1245 = 13 = 23423 = 134 = 125 = 45 = Block effect25 = 145 = 123 = 34 Design: Block X1 X2 X3 X4 X5 1 −1 1 −1 1 1 11 1 −1 −1 −1 −1 1 1 −11 1 −1 1 −1 −1 12 −1 −1 −1 12 1 1 −1 −1 −12 −1 1 1 1 1 1 29-7 29.26. b. The seven block effects are confounded with the following interaction terms: β135,β146, β236, β245, β1234, β1256, β3456 No, no c. Yi = β0Xi0 + β1Xi1 + · · ·+ β6Xi6 + β12Xi12 + · · ·+ β56Xi56 + β123Xi123 + · · ·+β456Xi456 + β1235Xi1235 + · · ·+ β2456Xi2456 + β12345Xi12345 + · · ·+β23456Xi23456 + β123456Xi123456 + α1Zi1 + · · ·+ α7Zi7 + εi where α1, ..., α7 are the block effects Coef. bq b0 63.922b1 2.297b2 5.797b3 2.172b4 2.359b5 2.828b6 2.922b12 .547b13 −.266b14 −.203b15 −.797b16 −.141b23 −.641b24 −1.141b25 .891b26 .047 Coef. bq b34 .297b35 .266b36 .984b45 −.422b46 −.141b56 .516b123 .422b124 .172b125 1.391b126 .984b134 .297b136 −.641b145 −.109b156 −.547b234 .234b235 .266 Coef. bq b246 −.391b256 .078b345 −.672b346 .734b356 −.734b456 −.234b1235 .578b1236 .922b1245 .453b1246 .109b1345 −.797b1346 .547b1356 −1.109b1456 −.109b2345 .328b2346 −.578 Coef. bq b2356 .766b2456 .203b12345 −.297b12346 −.391b12356 −.734b12456 −.422b13456 −.109b23456 .203b123456 .016Block 1 −4.172Block 2 −.422Block 3 1.203Block 4 6.703Block 5 −.797Block 6 −1.047Block 7 −9.547 29.27. a. Coef. bq P -valueb0 63.922b1 2.297 .000b2 5.797 .000b3 2.172 .001b4 2.359 .000b5 2.828 .000b6 2.922 .000b12 .547 .346b13 −.266 .645b14 −.203 .725b15 −.797 .172b16 −.141 .807b23 −.641 .270b24 −1.141 .054b25 .891 .128 Coef. bq P -valueb26 .047 .935b34 .297 .607b35 .266 .645b36 .984 .094b45 −.422 .466b46 −.141 .807b56 .516 .373Block 1 −4.172 .009Block 2 −.422 .782Block 3 1.203 .432Block 4 6.703 .000Block 5 −.797 .602Block 6 −1.047 .494Block 7 −9.547 .000 b. H0: Normal, Ha: not normal. r = .989. If r ≥ .9812 conclude H0, otherwise Ha.Conclude H0. 29-8 c. H0: βq = 0, Ha: βq 6= 0. s{αi} = 1.513 for block effects, s{bq} = .5719 for factoreffects. If P -value ≥ .01 conclude H0, otherwise Ha. Active effects (see part a):Block effects 1, 4, 7, all main effects 29.28. a. See Problem 29.27a for estimated factor and block effects. (These do not changewith subset model.) b. Maximum team effectiveness is accomplished by setting each factor at its highlevel. c. Yh = 82.297, s{pred} = 4.857, t(.975; 50) = 2.009, 82.297± 2.009(4.857), 72.54 ≤Yh(new) ≤ 92.05 29.29. a. Defining relation: 0 = 12345, resolution = V b. Yi = β0Xi0 + β1Xi1 + · · ·+ β5Xi5 + β12Xi12 + · · ·+ β35Xi35 + α1Zi1 + εi where α1 is the block effect Coef.
bq b0 113.18b1 26.69b2 −10.94b3 5.69b4 4.44b5 14.69b12 21.94b13 .56 Coef. bq b14 −1.44b15 −2.94b23 1.44b24 5.19b25 2.94b34 −3.44b35 −.94Block effect 2.27 d. H0: α1 = 0, Ha: α1 6= 0. s{α1} = 3.673, t∗ = 2.27/3.673 = .62, (.975; 6) = 2.447.If | t∗ |≤ 2.447 conclude H0, otherwise Ha. Conclude H0. e. Coef. bq P -valueb0 113.18b1 26.69 .000b2 −10.94 .011b3 5.69 .094b4 4.44 .169b5 14.69 .003b12 21.94 .001b13 .56 .847 Coef. bq P -valueb14 −1.44 .625b15 −2.94 .336b23 1.44 .625b24 5.19 .119b25 2.94 .336b34 −3.44 .268b35 −.94 .748 (Note: P -values based on MSPE; see part f.) H0: No lack of fit, Ha: lack of fit. SSLF = SSE − SSPE = 1, 894.4 − 609.5 =1, 284.9, F ∗ = (1, 284.9/2)÷(609.5/5) = 5.270, F (.95; 2, 5) = 5.786. If F ∗ ≤ 5.786conclude H0, otherwise Ha. Conclude H0. f. H0: βq = 0, Ha: βq 6= 0. MSPE = 121.90, s{bq} =√ 121.90/16 = 2.760. If P -value ≥ .025 conclude H0, otherwise Ha. Active effects (see part a): β1, β2, β5,β12 29.30. a. 29-9 Coef. bq b0 113.18b1 26.69b2 −10.94 Coef. bq b5 14.69b12 21.94 b. H0: Normal, Ha: not normal. r = .961. If r ≥ .954 conclude H0, otherwise Ha. Conclude H0 c. Set factors 1, 2, 5 at their high levels to maximize whippability. d. Yh = 165.56, s{Yh} = 8.03, t(.975; 17) = 2.110, 165.56 ± 2.110(8.03), 148.62 ≤E{Yh} ≤ 182.50 29.31. a. i 1 2 3 4 5 6 7 8s2 i 1.244 1.299 1.103 .992 1.966 1.916 1.589 1.576loge s2 i .218 .261 .098 −.008 .676 .650 .463 .455 i 9 10 11 12 13 14 15 16s2 i 2.201 1.818 1.901 1.547 1.681 1.020 1.033 1.151loge s2 i .789 .598 .642 .437 .520 .020 .033 .141 b. loge s2i = .3746−.0553Xi1−.0919Xi2−.0048Xi3+.0229Xi4+.0289Xi12+.0021Xi13− .0432Xi14−.0048Xi23+.0077Xi24−.2142Xi34+.0493Xi123+.0453Xi124−.0016Xi134− .0024Xi234 + .0284Xi1234 X34 appears to be active.
c. vi = 1.17395 (for i = 1, 2, 3, 4, 13, 14, 15, 16) vi = 1.80173 (for i = 5, . . . , 12) d.
Yi = 3.7082− .3754Xi1 e. From location model: X1 = +1; and from location model: (X3, X4) = (−1,−1) or(+1, +1) f. From dispersion model: s2 = exp(.3746− .2142) = 1.17395, and a 95% P.I. is (exp(.0453), exp(.2755)), or (1.0463, 1.3172). g. MSE = 1.17395 + 3.3332 = 12.284 29.32. a. i 1 2 3 4 5 6 7 8s2 i .0164 .0173 .0804 .1100 .0010 .0079 .0953 .1134loge s2 i −4.109 −4.058 −2.521 −2.207 −6.949 −4.838 −2.351 −2.176 b. loge s2i = −3.651+ .331Xi1 +1.337Xi2− .427Xi3− .275Xi4− .209Xi12 + .240Xi13 + .477Xi14. X2 appears to be active. c. vi = .00682 (for i = 1, 2, 5, 6) vi = .0989 (for i = 3, 4, 7, 8) d. Yi = 7.5800 + .0772Xi1 29-10 e. From the location model: X1 = +1; from the dispersion model: X2 = −1 f. From dispersion model: s2 = exp(−3.651 + 1.337(−1)) = .006819, and a 95% P.I. is (exp(−6.169), exp(−3.808)), or (.0021, .0222). g. MSE = .00682 + (8− 7.657)2 = .124 29.33. From (2.51), SSR(Xq) = b2q ∑(Xiq − Xq) 2. For coding in (29.2a), Xq = 0. Then: SSR(Xq) = b2q ∑X2 iq = b2q nT∑i=1 (±1)2 = nT b2q 29.34. a. E{β1} = E{(X′1X1) −1X′1Y} = (X′1X1) −1X′1E{Y} = (X′1X1) −1X′1(X1β1 + X2β2) = β1 + (X′1X1) −1X′1X2β2 = β1 + Aβ2 b. Let: β1 = β0 β1 β2 β3 β2 = β12 β13 β23 Then: X1 = 1 1 −1 −11 −1 1 −11 −1 −1 1 1 1 1 1 X2 = −1 −1 1 −1 1 −1 1 −1 −11 1 1 and: A = 0 0 0 0 1 0 1 0 1 0 0 The results follow from E{b1} = β1 + Aβ2. 29-11 29-12 Chapter 30 RESPONSE SURFACEMETHODOLOGY 30.2. Second block: X1 X2 X3 X4 2 0 0 0−2 0 0 0 0 2 0 00 −2 0 0 0 2 00 0 −2 00 0 0 20 0 0 −2 Any number of center points may be added to the second block. 30.7. a. 21 b.
5, 5, 10 c. 21, 27 30.8. 30-1 X1 X2 X3 X4 X5 −1 −1 −1 −1 −11 1 −1 −1 −11 −1 1 −1 −11 1 1 −1 −1 −11 −1 −1 1 −1 −11 1 −1 1 −1 −1 −1 1 1 −1 −1 1 1 1 −1 −1 −1 1 −1 −1 1 1 1 −1 1 1 1 1 −11 −1 −1 −1 1 −1 1 −1 1 −1 1 −1 1 −1 −1 −1 1 1 1 1 −1 1 −1 −1 1 1 1 1 1 −1 1 11 −1 1 1 1 −1 1 1 1 1 1 X1 X2 X3 X4 X5 2 0 0 0 0−2 0 0 0 0 0 2 0 0 00 −2 0 0 0 0 0 2 0 0 0 −2 0 0 0 0 0 2 0 0 0 −2 0 0 0 0 0 20 0 0 0 −20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 30.9. No, base design is resolution III. 30.10. α = [29−3(1)/(1)]1/4 = 2.828 30.11. b. Coef. bq P -valueb0 1.868b1 .190 .007b2 .195 .006b3 −.120 .039b12 .162 .020 Coef. bq P -valueb13 −.038 .471b23 −.062 .251b11 .228 .044b22 −.047 .602b33 .028 .757 d. H0: βq = 0, Ha: βq 6= 0. s{bq} = .0431 (for linear effects), s{bq} = .0481(for interaction effects), s{bq} = .0849 (for quadratic effects). If P -value ≥ .05conclude H0, otherwise Ha. Active effects (see part b): β1, β2, β3, β12, β11 30.12. a. Coef. bq b0 1.860b1 .190b2 .195 Coef. bq b3 −.120b12 .162b11 .220 b. H0: Normal, Ha: not normal. r = .947. If r ≥ .938 conclude H0, otherwise Ha.Conclude H0. 30.13.
a. Coef. bq b0 189.750b1 28.247b2 −.772 Coef. bq b12 13.750b11 −18.128b22 −6.875 30-2 c. H0: No lack of fit, Ha: lack of fit. SSLF = SSE − SSPE = 978.9 − 230.75 =748.15, F ∗ = (748.15/3) ÷ (230.75/3) = 3.24, F (.99; 3, 3) = 29.5. If F ∗ ≤ 29.5conclude H0, otherwise Ha. Conclude H0. e. (1.22, 1.16) f. Yh = 206.54, s{Yh} = 13.70, t(.975; 6) = 2.447, 206.54 ± 2.447(13.70), 173.0 ≤E{Yh} ≤ 240.1. 30.14. a. Design Matrix:X1 X2 −.707 −.707.707 −.707 −.707 .707.707 .707 −1 01 00 −10 10 00 00 00 00 00 00 00 0 Corner Points:X1 X2 −.707 −.707.707 −.707 −.707 .707.707 .707 b. (X′X)−1 = .125 0 0 −.125 −.125 00 .250 0 0 0 00 0 .250 0 0 0 −.125 0 0 .5 0 0−.125 0 0 0 .5 0 0 0 0 0 0 1 30.15. a. X1 X2 −1 −11 −1−1 1 1 1−1.414 0 1.414 00 −1.4140 1.414 X1 X2 0 00 00 00 00 0 n0 = 5 30-3 b. Variance function: .20− .075X21 − .075X2 2 + .14375X41 + .14375X4 2 + .2875X21X 22 30.16. a. b∗ = [−2.077 .724]s = 2.200 b. t X1 X2 1.5 −1.416 .4942.5 −2.361 .8233.5 −3.304 1.152 30.17. a. b∗ = 13.51913.494 −21.581 s = 28.820 b. t X1 X2 X3 −1 −.469 −.468 .749−2 −.938 −.936 1.498−3 −1.407 −1.404 2.246 30.18. a. Design Variance Function1 .6788− .5116X + .1710X2 − .02264X3 + .001029X4 2 .5266− .4048X + .1475X2 − .02012X3 + .000914X4 3 .6615− .4504X + .1393X2 − .01788X3 + .0008129X4 b. Design V1 .19932 .20373 .1869 Design 3 preferred c. Comparison EV Design 1 relative to design 2 1.02Design 1 relative to design 3 .94Design 2 relative to design 3 .92 1/.94 = 1.06 times d. Design | (X′X)−1 |1 6.35057 x 10−7 2 4.70419 x 10−7 3 5.57533 x 10−7 30-4 Design 2 preferred e.Comparison ED Design 1 relative to design 2 .90Design 1 relative to design 3 .96Design 2 relative to design 3 1.06 1/.90 = 1.11 times 30.19.
a. Design 2 is D-optimal b. Design 3 is V -optimal 30.20. a. Irregular c.Design V 1 .52352 .8962 Design 1 preferred d. EV = 1.712, 1/1.712 = .584 times e.Design | (X′X)−1 | 1 .3932 1.567 Design 1 preferred f. ED = .794, 1/.794 = 1.26 times 30.21. a. D-optimal design: | (X′X)−1 |= .2998 X1 X2 Number of Replicates−1 −1 1−.5 −1 1−.5 0 1 .25 0 10 1 21 1 1.5 1 2 No b. V -optimal design: V = .4765 X1 X2 Number of Replicates−1 −1 1−.5 −1 1−.5 0 1 .25 0 10 1 1.5 1 11 1 10 .25 2 30-5 No 30-6 Appendix D: RULES FORDEVELOPING ANOVA MODELSAND TABLES FOR BALANCEDDESIGNS D.1. i j kR R R E{MSA} E{MSB} E{MSAB}a b n Variance i j ij (ij)k αi 1 b n σ2α bn 0 0 0 βj a 1 n σ2β 0 an 0 0 (αβ)ij 1 1 n σ2αβ n n n 0 εk(ij) 1 1 1 σ2 1 1 1 1 D.2. a. Model Coef- Symbolic Term to Degrees ofTerm ficient Product be Squared Freedom αi bcn i− 1 Yi··· − Y···· a− 1βj acn j − 1 Y·j·· − Y···· b− 1γk abn k − 1 Y··k· − Y···· c− 1(αβ)ij cn ij − i− j + 1 Yij·· − Yi··· − Y·j·· + Y···· (a− 1)(b− 1)(αγ)ik bn ik − i− k + 1 Yi·k· − Yi··· − Y··k· + Y···· (a− 1)(c− 1)(βγ)jk an jk − j − k + 1 Y·jk· − Y·j·· − Y··k· + Y···· (b− 1)(c− 1)(αβγ)ijk n ijk − ij − ik Yijk· − Yij·· − Yi·k· − Y·jk· (a− 1)(b− 1)(c− 1) −jk + i + j + k − 1 +Yi··· + Y·j·· + Y··k· − Y····εm(ijk) 1 ijkm− ijk Yijkm − Yijk abc(n− 1) Total Yijkm − Y···· abcn− 1 D.1 b.i j k m Expected Mean Square of −−R R R R Vari- A B C AB AC BC ABC Ea b c n ance i j k ij ik jk ijk

(ijk)m αi 1 b c n σ2α bcn 0 0 0 0 0 0 0 βj a 1 c n σ2β 0 nac 0 0 0 0 0 0 γk a b 1 n σ2γ 0 0 abn 0 0 0 0 0 (αβ)ij 1 1 c n σ2αβ nc nc 0 nc 0 0 0 0 (αγ)ik 1 b 1 n σ2αγ nb 0 nb 0 nb 0 0 0 (βγ)jk a 1 1 n σ2βγ 0 na na 0 0 na 0 0 (αβγ)ijk 1 1 1 n σ2αβγ n n n n n n n 0 εm(ijk) 1 1 1 1 σ2 1 1 1 1 1 1 1 1 D.3. a. See Problem D.2a. b. i j k mExpected Mean Square of −− F R R R Vari- A B C AB AC BC ABC Ea b c n ance i j k ij ik jk ijk (ijk)m αi 0 b c n σ2α bcn 0 0 0 0 0 0 0 βj a 1 c n σ2β 0 nac 0 0 0 0 0 0 γk a b 1 n σ2γ 0 0 abn 0 0 0 0 0 (αβ)ij 1 1 c n σ2αβ nc 0 nc 0 0 0 0 (αγ)ik 1 b 1 n σ2αγ nb 0 0 0 nb 0 0 0 (βγ)jk a 1 1 n σ2βγ 0 na na 0 0 na 0 0 (αβγ)ijk n 0 0 n n 0 n 0 εm(ijk) 1 1 1 1 σ2 1 1 1 1 1 1 1 1 D.4. a. Model Symbolic Degrees ofTerm Product Sum of Squares Freedom βj j − 1 an∑ (Y·j· − Y···)2 b− 1αi(j) ij − j n ∑ ∑(Yij· − Y·j·)2 b(a− 1) εk(ij) ijk − ij∑ ∑ ∑ (Yijk − Yij·)2 ab(n− 1) Total∑ ∑ ∑ (Yijk − Y···)2 abn− 1 b. j i kF R R Vari- E{MSB} E{MSA(B)} E{MSE}b a n ance j i(j) (ij)k βj 0 a n σ2β an 0 0 αi(j) 1 1 n σ2α n n 0 εk(ij) 1 1 1 σ2 1 1 1 D.2 E{MSB} =an ∑β2 j b−1+ nσ2 α + σ2 E{MSE} = σ2 E{MSA(B)} = nσ2α + σ2 c. MSA(B) D.5. a. Model Coef- Symbolic Term to be Degrees ofTerm ficient Product Squared Freedom ρi r i− 1 Yi· − Y·· n− 1τj nb j − 1 Y·j − Y·· r − 1 Error Remainder = Remainder =Yij − Yi· − Y·j + Y·· (r − 1)(nb − 1) Total Yij − Y·· rnb − 1 b. i jF F Vari- E{MSBL} E{MSTR} E{MSE}nb r ance i j (ij) ρi 0 r σ2ρ r 0 0 τj nb 0 σ2τ 0 nb 0 ε(ij) 1 1 σ2 1 1 1 D.6. a. See Problem D.5a. b. i jF R Vari- E{MSBL} E{MSTR} E{MSE}nb r ance i j (ij) ρi 0 r σ2ρ r 0 0 τj nb 1 σ2τ 0 nb 0 ε(ij) 1 1 σ2 1 1 1 D.7. a. See Problem D.5a. b. i jR F Vari- E{MSBL} E{MSTR} E{MSE}nb r ance i j (ij) ρi 1 r σ2ρ r 0 0 τj nb 0 σ2τ 0 nb 0 ε(ij) 1 1 σ2 1 1 1 D.3 D.8. a. Model Coef- Symbolic Degrees ofTerm ficient Product Term to be Squared Freedom ρi rm i− 1 Yi·· − Y··· nb − 1τj nbm j − 1 Y·j· − Y··· r − 1ε(ij) m Remainder = Remainder = Yij· − Yi·· − Y·j· + Y··· (nb − 1)(r − 1)ηk(ij) 1 ijk − ij Yijk − Yij· nbr(m− 1) Total Yijk − Y··· nbrm− 1 SSBL = rm∑ (Yi·· − Y···)2 SSEE = m∑ ∑ (Yij· − Yi·· − Y·j· + Y···)2 SSTR = nbm∑ (Y·j· − Y···)2 SSOE =∑ ∑ ∑ (Yijk − Yij·)2 b. i j k R F R Vari- E{MSBL} E{MSTR} E{MSEE} E{MSOE}nb r m ance i j (ij) (ij)k ρi 1 r m σ2ρ rm 0 0 0 τj nb 0 m σ2τ 0 nbm 0 0 ε(ij) 1 1 m σ2 m m m 0ηk(ij) 1 1 1 σ2 η 1 1 1 1 E{MSBL} = rmσ2ρ + mσ2 + σ2 η E{MSEE} = mσ2 + σ2η E{MSTR} =nbm ∑τ2j r−1+ mσ2 + σ2 η E{MSOE} = σ2η D.9. a. Model Symbolic Degrees ofTerm Product Sum of Squares Freedom αi i− 1 bcn∑ (Yi··· − Y····)2 a− 1βj(k) jk − k an ∑ ∑(Y·jk· − Y··k·)2 c(b− 1) γk k − 1 abn∑ (Y··k· − Y····)2 c− 1(αγ)ik ik − i− k + 1 bn ∑ ∑(Yi·k· − Yi··· − Y··k· + Y····)2 (a− 1)(c− 1) (αβ)ij(k) ijk − ik − jk + k n∑ ∑ ∑ (Yijk· − Yi·k· − Y·jk· + Y··k·)2 (a− 1)(b− 1)cεm(ijk) ijkm− ijk ∑ ∑ ∑ ∑(Yijkm − Yijk·)2 abc(n− 1) Total∑ ∑ ∑ ∑ (Yijkm − Y····)2 abcn− 1 D.4 b. i j k mExpected Mean Square of −− F R R R Vari- A B(C) C AC AB(C) Ea b c n ance i j(k) k ik ij(k) m(ijk) αi 0 b c n σ2α bcn 0 0 0 0 0 βj(k) a 1 1 n σ2β 0 an an 0 0 0 γk a b 1 n σ2γ 0 0 abn 0 0 0 (αγ)ik 0 b 1 n σ2αγ bn 0 0 bn 0 0 (αβ)ij(k) 0 1 1 n σ2αβ n 0 0 n n 0 εm(ijk) 1 1 1 1 σ2 1 1 1 1 1 1 E{MSA} =bcn ∑α2 i a−1+ bnσ2 αγ + nσ2αβ + σ2 E{MSB(C)} = anσ2β + σ2 E{MSC} = anσ2β + abnσ2 γ + σ E{MSAB(C)} = nσ2αβ + σ2 E{MSAC} = bnσ2αγ + nσ2 αβ + σ2 E{MSE} = σ2 D.10. eijk :j = 1 j = 2 j = 3 k = 1 −2.3333 .3333 −1.6667i = 1 k = 2 1.6667 −1.6667 .3333 k = 3 .6667 1.3333 1.3333k = 1 −.3333 2.3333 −1.0000 i = 2 k = 2 1.6667 −.6667 .0000k = 3 −1.3333 −1.6667 1.0000k = 1 −1.6667 −1.6667 −1.3333 i = 3 k = 2 1.3333 1.3333 .6667k = 3 .3333 .3333 .6667 r = .981 D.11. a.

Source SS df MSBlocks 520.963 2 260.4815Treatments 103.185 2 51.5925Experimental error 5.259 4 1.3148Observation error 45.333 18 2.5185Total 674.741 26 b. H0 : all τj equal zero (j = 1, 2, 3), Ha : not all τj equal zero. F ∗ = 51.5925/1.3148 =39.24, F (.95; 2, 4) = 6.94. If F ∗ ≤ 6.94 conclude H0, otherwise Ha. Conclude Ha.P−value = .002. c. Y·1· = 24.77778, Y·2· = 20.00000, Y·3· = 22.66667, L1 = Y·1· − Y·2· = 4.77778,L2 = Y·1·− Y·3· = 2.11111, L3 = Y·2·− Y·3· = −2.66667, s{Li} = .5405 (i = 1, 2, 3),q(.90; 3, 4) = 3.98, T = 2.8143 4.77778 ± 2.8143(.5405) 3.257 ≤ L1 ≤ 6.299 D.5 2.11111 ± 2.8143(.5405) .590 ≤ L2 ≤ 3.632 −2.66667 ± 2.8143(.5405) − 4.188 ≤ L3 ≤ −1.146 d. σ2 = 0, σ2η = 2.5185 D.12. a. Model Coef- Symbolic Term to Degrees ofTerm ficient Product Be Squared Freedomρi ab i− 1 Yi·· − Y··· s− 1αj sb j − 1 Y·j· − Y··· a− 1βk sa k − 1 Y··k − Y··· b− 1(αβ)jk s jk − j − k + 1 Y·jk − Y·j· − Y··k + Y··· (a− 1)(b− 1)Error Remainder = Remainder = Yijk − Yi·· − Y·jk + Y··· (s− 1)(ab− 1) Total Yijk − Y··· abs− 1 b. i j kExpected Mean Square of −− R F F Vari- S A B AB Rems a b ance i j k jk (ijk) ρi 1 a b σ2ρ ab 0 0 0 0 αj s 0 b σ2α 0 sb 0 0 0 βk s a 0 σ2β 0 0 sa 0 0 (αβ)jk s 0 0 σ2αβ 0 0 0 s 0 ε(ijk) 1 1 1 σ2 1 1 1 1 1 D.13. a. Model Coef- Symbolic Term to Degrees ofTerm ficient Product Be Squared Freedom αj bs j − 1 Y·j· − Y··· a− 1βk as k − 1 Y··k − Y··· b− 1(αβ)jk s jk − j − k + 1 Y·jk − Y·j· − Y··k + Y··· (a− 1)(b− 1)ρi(j) b ij − j Yij· − Y·j· a(s− 1)Error Remainder = Remainder = Yijk − Y·jk − Yij· + Y·j· a(s− 1)(b− 1) Total Yijk − Y··· abs− 1 D.6 b. j k iExpected Mean Square of −− F F R Vari- A B AB S(A) Rema b s ance j k jk i(j) (ijk) αj 0 b s σ2α bs 0 0 0 0 βk a 0 s σ2β 0 as 0 0 0 (αβ)jk 0 0 s σ2αβ 0 0 s 0 0 ρi(j) 1 b 1 σ2ρ b 0 b 0 ε(ijk) 1 1 1 σ2 1 1 1 1 1 D.14. Note: The subscript for subjects here is l instead of the usual i and the subscripts forfactor A, B, and C are i, j, and k, respectively. a. Yijklm = μ···· + αi + βj + γk + ρl(ik) + (αβ)ij + (αγ)ik + (βγ)jk +(αβγ)ijk + εm(ijkl) b. Model Coef- Symbolic Term to Degrees ofTerm ficient Product Be Squared Freedom αi bcrn i− 1 Yi···· − Y····· a− 1βj acrn j − 1 Y·j··· − Y····· b− 1γk abrn k − 1 Y··k·· − Y····· c− 1ρl(ik) abcn ikl − ik Yi·kl· − Yi·k·· ac(r − 1)(αβ)ij crn ij − i− j + 1 Yij··· − Yi···· − Y·j··· + Y····· (a− 1)(b− 1)(αγ)ik brn ik − i− k + 1 Yi·k·· − Yi···· − Y··k·· + Y····· (a− 1)(c− 1)(βγ)jk arn jk − j − k + 1 Y·jk·· − Y·j··· − Y··k·· + Y····· (b− 1)(c− 1)(αβγ)ijk rn ijk − ik − jk Yijk·· − Yi·k·· − Y·jk·· − Yij··· (a− 1)(b− 1)(c− 1) −ij + i + j + k − 1 +Yi···· + Y·j··· + Y··k·· − Y·····Error Remainder = Remainder = Yijklm − Yi·kl· − Yijk·· + Yi·k·· abcrn− acr − abc + ac Total Yijklm − Y····· abcrn− 1 SSA = bcrn∑ (Yi···· − Y·····)2 SSB = acrn∑ (Y·j··· − Y·····)2 SSC = abrn∑ (Y··k·· − Y·····)2 etc. D.7 c. i j k l mF F F R R a = 3 b = 4 c = 2 r = 4 n = 2 Varianceαi 0 b c r n σ2 α βj a 0 c r n σ2β γk a b 0 r n σ2γ ρl(ik) 1 b 1 1 n σ2ρ (αβ)ij 0 0 c r n σ2αβ (αγ)ik 0 b 0 r n σ2αγ (βγ)jk a 0 0 r n σ2βγ (αβγ)ijk 0 0 0 r n σ2αβγ εm(ijkl) 1 1 1 1 1 σ2 Expected Mean Square of −−A B C S(AC) AB AC BC ABC Ei j k l(ik) ij ik jk ijk m(ijkl) αi bcrn 0 0 0 0 0 0 0 0βj 0 acrn 0 0 0 0 0 0 0γk 0 0 abrn 0 0 0 0 0 0ρl(ik) bn 0 bn bn 0 bn 0 0 0(αβ)ij 0 0 0 0 crn 0 0 0 0(αγ)ik 0 0 0 0 0 brn 0 0 0(βγ)jk 0 0 0 0 0 0 arn 0 0(αβγ)ijk 0 0 0 0 0 0 0 rn 0εm(ijkl) 1 1 1 1 1 1 1 1 1 E{MSA} = 64∑ α2 i 2+ 8σ2 ρ + σ2 E{MSB} = 48∑ β2 j 3+ σ2 E{MSC} = 96∑ γ2 k 1+ 8σ2 ρ + σ2 E{MSS(AC)} = 8σ2ρ + σ2 E{MSAB} = 16∑ ∑ (αβ)2 ij 6+ σ2 E{MSAC} = 32∑ ∑ (αγ)2 ik 2+ 8σ2 ρ + σ2 E{MSBC} = 24∑ ∑ (βγ)2 jk 3+ σ2 E{MSABC} = 8∑ ∑ ∑ (αβγ)2 ijk 6+ σ2 E{MSE} = σ2 D.8 D.15. i j kF F F Vari- E{MSROW} E{MSCOL} E{MSTR} E{MSE}r r r ance i j k (ijk) ρi 0 r r σ2ρ r 0 0 0 κj r 0 r σ2κ 0 r 0 0 τk r r 0 σ2τ 0 0 r 0 ε(ijk) 1 1 1 σ2 1 1 1 1 D.16. i j k mF F F R Vari- E{MSROW} E{MSCOL} E{MSTR} E{MSRem}r r r n ance i j k m(ijk) ρi 0 r r n σ2ρ rn 0 0 0 κj r 0 r n σ2κ 0 rn 0 0 τk r r 0 n σ2τ 0 0 rn 0 εm(ijk) 1 1 1 1 σ2 1 1 1 1 E{MSROW} = σ2 +rn ∑ρ2 i r − 1E{MSTR} = σ2 + rn∑ τ 2k r − 1 E{MSCOL} = σ2 +rn ∑κ2 j r − 1E{MSRem} = σ2 D.17. i j k mExpected Mean Square of −− F F F R Vari- P O TR S(P) Remr r r n ance i j k m(i) (ijkm) ρi 0 r r n σ2ρ rn 0 0 0 0 κj r 0 r n σ2κ 0 rn 0 0 0 τk r r 0 n σ2τ 0 0 rn 0 0 ηm(i) 1 r r 1 σ2η r 0 0 r 0 ε(ijkm) 1 1 1 1 σ2 1 1 1 1 1 1 D.9