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From the Selected Works of Joseph M Hilbe

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ERRATA Negative Binomial Regression 1st edition 1st print

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Available at: https://works.bepress.com/joseph_hilbe/27/
ERRATA : Negative Binomial Regression

FIRST PRINTING. Note – Most of the errata below has been fixed in the second
printing of the book, which was available in Europe beginning 1 December 2008, and
US/North America about 15 December. In addition, other enhancements and updating
were made to the second printing. Several items below are simply comments.

5 January, 2010

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PREFACE
p. x: 2nd line of 3rd complete paragraph. Web address (same as on copyright page):
“www.cambridge.org/XXXXXX” should read  www.cambridge.org/9780521857727”.

INTRODUCTION
p. 1: Last word of first sentence. The word “model” should be replaced by “distribution”.

p. 2: 12th line in top paragraph. “binomial” misspelled.

p. 2: last sentence of first paragraph: The SPSS generalized linear models procedure name is
mistaken. It is GENLIN, not GLZ (Statistica).

CHAPTER 2

p. 20, 1st paragraph, line 8: Add “family”, so that the line should read: “link, variance, and family
functions. The algorithm took care …”

p. 21: line 2: First word of line reads “or”. It should read "and".

p. 22: Equation 2.6 : Should read:  \( X_1 = X_0 - f(X_0)/f'(X_0) \)
+ : Equation 2.8 : 2nd equation has a missing “=” sign. Should read  \[ \partial^2 L = \partial^2 L/\partial \beta \partial \beta^* \]
+ : Equation 2.12; replace \( \partial L/\partial \beta_j \) with simply \( L \).

Equation 2.13 should not have the 2nd equals sign

p.23: Equation 2.14; replace denominator on left hand side term with \( \hat{\beta}_j \)
index should be given denominator of last term: \( \alpha_i(\phi) \)

P. 27, Table 2.1, AIC statistic note: The note to the program line defining the AIC statistic reads:
“/* AIC is sometimes defined w/o \( \eta \) */”. The last term, \( \eta \), should read, n, not \( \eta \). See comments
below.

p. 27, 8th line under Table 2.1 Line to amend reads: “…function; BIC represents the Bayesean
Information Criterion, which is usually based on the deviance value.” “Bayesean” should be
spelled “Bayesian”, and the sentence following semicolon should read: “… function; BIC represents the Bayesian Information Criterion, which was originally based on the deviance, but is now usually formulated in terms of the log-likelihood.”

p. 28, Section 2.2. Replace paragraph with the following: “In this section we discuss the derivation of the Newton-Raphson type algorithm. Until recently, the only method used to estimate the standard negative binomial model was by maximum likelihood estimation using a Newton-Raphson based algorithm. All other varieties of negative binomial are still estimated using a Newton-Raphson based routine. We shall observe in this section though, that the Iteratively Re-weighted Least Squares method we discussed in the last section, known as Fisher Scoring, is a subset of the Newton-Raphson method. We conclude by showing how the parameterization of the GLM mean, $\mu$, can be converted to $X'\beta$.”

CHAPTER 3

p. 32, Table 2.4. Amend the line near bottom of table beginning with BIC, to read:

```
BIC = DEV - (dof)ln(n) /// or -2LL + ln(n)*k (Stata version);
    k=# predictors
```

p. 34. The first equations should not have $/d[\theta]$. $b'$ and $'''$ indicate differentiation. The next equation (just after section 2.4), is missing the covariates in the linear response, e.g. $\beta_1 x_1$, etc.

p. 35 (near bottom of page) Should read “hypergeometric2F1”, not “hypergeometricx2F1”. Same problem for top of page 36

p. 40, 1st line under equation 2.53. “caste” should be spelled “cast”.

p. 40: equation 3.7 should read: $\mu = \exp(\eta)$

p. 40: equation 3.8 left side of initial $=$ sign should read: $b'(\theta)$

p. 42: line 3 of Table 3.1 should read: WHILE (abs(\Delta dev) > tolerance) {

p. 42: Equation 3.20: delete minus sign in front of $\Sigma$

p. 47, equation 3.23: There should be an equal sign between $Z_i$ and the other terms

p. 47, code at bottom of page. First line of code, “predict xb” should read, “predict mu” - and the second line deleted “gen mu=exp(xb)” OR: it can read “predict xb, xb”, and leave the second line as is.

p. 48, Equation 3.24. The y in the numerator should have a bar over it, indicating that it is the mean of y.

p. 48, code in middle of page. List line with leading dot. “n” should read “_n”. The line should now appear as: display “LM value =” chival _n “p-value =”
CHAPTER 4

p. 52, second to last line of program code on page. Line should read: . gen xb = 1 + .5*x1 - .75*x2 + .25*x3

p. 52: Line before Stata commands at bottom of page: Should be in regular font.

p. 56: last number at bottom right of page: Upper CI should read 1.015039

p. 63: last line of code in Table 4.1: It should read: "w = 1/sqrt(sc)" instead of "w = µ/sqrt"

p. 64: Section 4.3.2: 1st line: Should read “Wedderburn”

p. 73, 6th line of Stata commands: should read: . di 20.02131 + .3*20.02312^2 /* mean + alpha*mean^2 */

CHAPTER 5

p. 77, 5th line from top: delete word ‘model’.

p. 78. Table 5.1: The last two items should be numbered 24 and 25, and not 22 and 22.

p. 80: Equations 5.3 and 5.4: numerator of 2nd term should read v. Both are v (nu)

p. 82: 3rd line from top. Delete “would be” and substitute, “is”.

4th line from top. Delete “; only to limit r as positive.” Period at end.

p. 82: Equations 5.19 and 5.20: The “choose” functions should not have a division sign between top and bottom terms. See Equation 5.29 as an example. \( \binom{y + r - 1}{r - 1} \)

p. 82: Equation 5.25: last term before final = should read \( -r/p \) (-1-p))

p. 83: Equations 5.30 and 5.31: delete “exp” following \( \Sigma \).

p. 83: Line directly under Eq 5.32 should read:
“Substituting the log-likelihood function as specified in either Equation (5.30) or
Equation (5.31), we have”

p. 83: Equation 5.33. Drop second \( \alpha \). 2nd term of deviance should be \(-(y+1/\alpha)\) only.

p. 84: Equation 5.35. The formula should appear as:
\[
g^{-1}(\theta) = \mu = 1/\{\alpha(e^\theta - 1)\}
\]
p. 84: Equation 5.41. I have calculated a less complex formula, which reads as:

\[ L = y(xb) + (1/\alpha) \ln(1-\exp(xb)) + \ln\Gamma(y+1/\alpha) - \ln\Gamma(y+1) – \ln\Gamma(1/\alpha) \]

Note that this new formula is in the revised version of the Stata `cnbreg` command. It is posted to SSC; i.e., type at the Stata command line: `. ssc install cnbreg`

p. 90: Figure 5.11: Table, change “po5” to “P: mean=10”
Caption: change “...: mean = 5” to “...: mean = 10”

p. 94: value of variance under the word “hence”: In the list of formulae there are two equations with a left hand side of \( V(\mu) \). The 2nd of these two equations should read \( V'(\mu) \) instead of \( V(\mu) \). Therefore \( V'(\mu) = 1 + 2\alpha\mu \)

p. 95: table 5.5, 1st line in loop: Should read: \( w = (\mu/\alpha\mu) + (y-\mu)(\alpha\mu/(1+2\alpha\mu+\alpha^2+\mu^2)) \)

p. 96: Section 5.5, lines 6-7: Should be “two-parameter”, not “one-parameter”, and parameter, not function. The two lines should read:

“Poisson variance and \( \mu^2/\nu \) the two-parameter gamma distribution variance. We inverted the gamma scale parameter, \( \nu \) to \( \alpha \), the negative binomial ancillary or …”

p. 96: Section 5.5, Paragraph 3, line 2. Delete comma between “version” and “of”.

CHAPTER 6

p.108: Table 6.6, title of 1st column is "years", should be "naffairs".

p. 112: Formula for the negative binomial variance is mistaken. Should read: \( \mu + \alpha\mu^2 \)

The formula as it currently reads is missing \( \alpha \) in the 2nd term.

p.113: beginning of 3rd line, should be "In any case,..."

p.117: Table 6.9, header of 5th column should read “Percent”

p.119: 2nd paragraph, line 4, "ZINB" should be "ZTNB"

p. 119: Example 3, first line: “log” rather than “data”

Should read: “These data come from the 1912 Titanic survival log. It consists…”

p.125: Caption for Table 6.13, "Tabulation" is misspelled

p.125: Table 6.13, 1st column should read, “MD visits”

p. 126: 3rd sentence under Table 6.14. Insert word “the” as follows:

“…household income, Age and education are not contributory to the model. Recall…”
p.127: beginning of 2nd paragraph, “Edu” should be “Educ”.

p. 128: line under first table display on top of page: Delete the “?” which is at the end of the line.

CHAPTER 7

p. 136: Paragraph 2, line 4, first word: Word “variance” should read “assumptions”. Line 4 of 2nd paragraph should start out as “assumptions of the Poisson distribution. Other models are …”

p.137: Table 7.1, line beginning "NB-P", exponent appears as "rho", but should be "p".

p.137: Eqs 7.1 and 7.2, 1st "exp" should be omitted

p.138: Eqs 7.3 and 7.4, 1st "exp" should be omitted

p.138: top line on page, change to read: “Parameterized in terms of the log link function ln(μ ) = x_i β or ln(μ) = x_i b [also \( x\beta \) or \( xb \)], “

p. 139, line 3 under table of parameter estimates, 1st word of line: Word “restricted” should be changed to “expected”. The line should read, in part: “expected for a geometric model. Recall that unless …”

p.141: Eq 7.13, CUMULANT= -ln(p)

p.141: Eq 7.17, "exp" should be omitted

p. 143, 2nd last line of last full paragraph. Replace term “Figure 7.1” with “Figure 7.2”.

p.145: 1st line after top table, equation to read: \( \phi = (1+\alpha) = 1.503 \).

p. 146: Eq 7.25, integrand is missing a \( \lambda^{i-1} \) after 2nd term.

p. 146: Line under Eq 7.25: Should read: “Changing \( \lambda \) to \( \mu \) and solving to clear the integration, we have”

p.146: Eq 7.27, \( \Gamma(\mu+1) \) in denominator should be \( \Gamma(y+1) \)

p.146: Eq 7.28, \( \Gamma(\mu+1) \) in denominator should be \( \Gamma(y+1) \); drop \( d\mu \)

p.147: 1st line after Eq 7.32, should read as "The variance to mean ratio is \( (1+\delta)/\delta, \ldots \)"

p. 153, last two lines on page. Should read: \[-2\left\{(-60322.021) - (-60258.97)\right\}

\[
= 126.102
\]

p. 154, second line top paragraph: Should read: \[ \text{Chi2tail}(1,126.102) = 2.921e-29. \]

p. 155, 1st Eq on page the exponent, 2, should be changed to \( y \).

p. 158, First paragraph of section 7.6, "assumptions" is misspelled

p. 163: Wald statistic in bottom output (header): The Wald chi2(2) is now reported as a Likelihood Ratio test (LR test) in Stata’s `ztnb` command. The output was created in a program by the same name I wrote before Stata offered the command. Published on the SSC site, Stata Corp used it as the basis of the new command, with LR rather than Wald, which came automatically with all ML estimations.

CHAPTER 8

p.161: Eq 8.1, term over Σ should be n, not i=1

p.161: Eq 8.2, exponent is "-1/a", should be " -1/α"

p.171, bottom-page model output. Negative binomial age3 coefficient should read: .023721. The decimal point was inadvertently dropped.

p. 172, AIC Formula should read: \( \text{AIC}_{\text{hurdle}} = \left( (\text{AIC}_{\text{ZT}} \times (1 - N_{>0}/N) + \text{AIC}_{\text{binary}} \right) \)

p. 174, Final full paragraph, final 4 lines: The three terms predicting zero counts are parameterized in terms of \( \mu \) rather than \( x\beta \), as shown in the two formulae mid-page. To be consistent, the discussion should be in terms of \( x\beta \) in both places. The last 4 lines should read: “zero count are; (1) logistic inverse link, i.e. \( 1/(1+\exp(-x\beta)) \), the prediction that \( y==1 \), (2) 1- \( 1/(1+\exp(-x\beta)) \), and (3) the negative …”

CHAPTER 9

p. 180, Section 9.1.1, 2nd paragraph, line 3: “lower” should read “higher”, comma to semicolon: Therefore, the line should read: “wish to extend C to any higher value in the observed distribution; the value to”

p. 181, Header for bottom table: Should read: “POISSON: DROPPED VALUES 0-3”

p.183, Last symbol of equation 9.9 should be \( \alpha \), not 'a'

p. 193, line 2 under top table of parameter estimates: “selection” instead of “selected”. The sentence should therefore read: “to the selection corrected Poisson”.

CHAPTER 10

p. 213-225, panel models using the `progabide` data. It is preferable to use i(id) and t(t) options. Both make sense, but using the above two options are more sensical and result in a better interpreted model.

p. 221: Stata command at bottom of page. Delete 't(id)' since time panel not applicable for structure.
p. 223, reword from 4th line of text: “… decreases by a 1-unit increase in power of the previous diagonal. One might … The depiction here is true for this example, but not for all AR levels or structures.”

p. 226, Section 10.5, line 1: “also” should read “sometimes”. Line should read: “Multilevel models are sometimes called hierarchical models, particularly …”. For clarification purposes, I add an additional sentence after the first. The first three sentences of the paragraph should then read: “Multilevel models are sometimes called hierarchical models, particularly in educational and social science research. However, the majority of statisticians now tend to draw a distinction between multilevel and hierarchical models, primarily because of the manner in which the methods define order of levels, or nesting. Regardless, the idea behind multilevel modeling is to model the dependence that exists…”

NOTE: Chapter 10 has been rewritten and can be downloaded from: http://www.statistics.com/hilbe/nbr.php

p. 227, After equation 10.21, 2nd subscript on y should be 'k', not 't'

Pages 85-90 Graphs
The lack of color in the book makes it difficult to determine which line is associated with a specific mean and/or alpha. For Figures 5.1 – 5.6, which show different means for the same value of alpha (\( \alpha \)), the values of the mean from top to bottom at count 0, are: \([0.5, 1, 2, 5, 10]\). For Figures 5.7 - 5.11, the values of alpha for a specific mean, from top to bottom at count 0, are \([3, 1.5, 1, .67, .33, 0]\). The BOOK COVER is the same as Figure 5.10.

CH 10: GEE models using progabide data
The version of the Stata software used for developing GEE models using the progabide data did not recognize that the stationary, nonstationary, and unstructured correlation structures are infeasible for this data; i.e. the algorithm did not recognize that the correlation structure was not positive definite. The correlation matrix for these specific models are not reliable. The software has since been amended to display an error message when the matrix is infeasible, and will not produce a table of estimates or a post-estimation correlation matrix. Stata versions 9.2 and higher work as they should; I am not certain at which lower version the xtgee command was amended. I suggest that the reader ignore the inherent unreliability of these specific model results, reading the text and its interpretation as if appropriate convergence was achieved – as it appears in the output. The pedagogical value of the discussion is nevertheless valid. The correlation values produced, together with parameter estimates and standard errors, appear to be reasonable, and can be used with value in demonstrating how the models are to be estimated and evaluated. The “stationary 4” correlation structure is feasible for this data, unlike other stationary correlation structures. It can be developed using the command: . xtgee seizures time timeXprog, fam(poi) i(id) t(t) corr(stat 4) force.

It is important to use the force option when time intervals are not all equal. If in fact the time intervals are equal, do not use the force option.

APPENDIX A
p. 233: Not an error, but an improvement. Amend LL function for NEGATIVE BINOMIAL CANONICAL to:

\[
y(xb) + (1/\alpha)\ln(1-exp(xb)) + \ln\Gamma(y+1/\alpha) - \ln\Gamma(y+1) - \ln\Gamma(1/\alpha)
\]

p. 234 Not an error, but an addition: Add ZERO-TRUNCATED POISSON

\[
y(xb) - \exp(xb) - \ln\Gamma(y+1) - \ln(1-\exp(-\exp(xb)))
\]