

# ERRATA AND COMMENTS

## Negative Binomial Regression

Joseph M. Hilbe

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**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.

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AUTHOR EMAIL: [Hilbe@asu.edu](mailto:Hilbe@asu.edu); [j.m.hilbe@gmail.com](mailto:j.m.hilbe@gmail.com)

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### PREFACE

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

### INTRODUCTION

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

p. 2: 12<sup>th</sup> 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, 1<sup>st</sup> 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 : 2<sup>nd</sup> 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  $L$ .

p. 23: Equation 2.14; replace denominator on left hand side term with  $\partial \beta_i$

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, 8<sup>th</sup> line under Table 2.1 Line to amend reads: “...function; BIC represents the Baysean Information Criterion, which is usually based on the deviance value.” “Baysean” 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. 40, 1<sup>st</sup> 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 =  $\mu$ /sqrt”

p. 64: Section 4.3.2: 1<sup>st</sup> line: Should read “Wedderburn”

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

## CHAPTER 5

p. 77, 5<sup>th</sup> 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 2<sup>nd</sup> term should read  $v^v$ . Both are  $v$  (nu)

p. 82: 3<sup>rd</sup> line from top. Delete “would be” and substitute, “is”.  
4<sup>th</sup> 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. 
$$\frac{(y + r - 1)}{(r - 1)}$$

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  $\alpha$ . 2<sup>nd</sup> 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: Eq 5.36-5.37. Delete Eq 5.36, or place a negation in front of it. Eq 5.37 should appear as  $(1/\alpha) * \ln(1+\alpha\mu)$

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 2<sup>nd</sup> of these two equations should read  $V'(\mu)$  instead of  $V(\mu)$ . Therefore  $V'(\mu) = 1 + 2\alpha\mu$

p. 95: table 5.5, 1<sup>st</sup> 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  $\mu^2/v$  the two-parameter gamma distribution variance. We inverted the gamma scale parameter,  $v$  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 “affaires”.

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 2<sup>nd</sup> 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: 3<sup>rd</sup> 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 2<sup>nd</sup> 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, 1<sup>st</sup> "exp" should be omitted

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

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

p. 139, line 3 under table of parameter estimates, 1<sup>st</sup> 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, 2<sup>nd</sup> 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  $\lambda^{\mu-1}$  after 2<sup>nd</sup> 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  $(1+\delta)/\delta$ , ...”

p. 153, last two lines on page. Should read: 
$$-2\{(-60322.021) - (-60258.97)\} / 126.102$$

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

p. 155: 1st Eq on page should be changed to:

$$f(y; \mu, \alpha) = (\mu/(1+\alpha\mu))^y (1+\alpha y)^{y-1} / y! \exp[-\mu(1+\alpha y)/(1+\alpha \mu)]$$

p. 155, 7<sup>th</sup>-6<sup>th</sup> line from bottom: Yang, Hardin, and Addy (2006), not 2007.

p. 163: Wald statistic in bottom output (header):

The Wald  $\chi^2(2)$  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  $\Sigma$  should be  $n$ , not  $i=1$

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

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:  $AIC_{\text{hurdle}} = ((AIC_{ZT} * (1-N_{>0}/N) + AIC_{\text{binary}}$

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, 2<sup>nd</sup> 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. 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. 216: Eq 10.18 should read  $r_{ik} = \Sigma(y_{ik} - \mu_{ik}) / \text{sqrt}(V(\mu_{ik}))$

Next line should read:

"The Poisson Pearson residual is defined as  $\Sigma(y_{ik} - \mu_{ik}) / \text{sqrt}(\mu_{ik})$ "

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 4<sup>th</sup> 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>

### 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

$$y(xb) - \exp(xb) - \ln\Gamma(y+1) - \ln(1-\exp(-\exp(xb)))$$