

# A

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## Probability Generating Functions

This appendix is based on Feller (1968, Chap. XI and Chap. XII). Let  $X$  be a random variable taking values  $j \in \mathcal{N}_0$  with  $P(X = j) = p_j$ . Upper case letters  $X, Y$ , and  $Z$  denote a random variable, while lower case letters  $j$  and  $k$  denote a realization.  $p_{j \in \mathcal{N}_0}$  is called the *probability function*, while  $F_{i \in \mathcal{N}_0} = P(X \leq i)$  is called the *distribution function*.

### Definition 1.

Let  $X$  be a random variable defined over the non-negative integers. The probability generating function (PGF) is given by the polynomial

$$\mathcal{P}^{(X)}(s) = p_0 + p_1 s + p_2 s^2 + \dots = \sum_{j=0}^{\infty} p_j s^j = E(s^X) \quad (\text{A.1})$$

The function  $\mathcal{P}(s)$  is defined by the  $p'_j s$  and, in turn, defines the  $p'_j s$  since a polynomial expansion is unique.

**Example:** Let  $X$  have a binomial distribution function with parameters  $n$  and  $p$ ,  $p_j = 0$  for  $j > n$  (writing  $X \sim B(n, p)$ ). The probability generating function is given by

$$\mathcal{P}(s) = \sum_{j=0}^n \binom{n}{j} (ps)^j q^{n-j} = (q + ps)^n \quad (\text{A.2})$$

If it is not clear out of the context which random variable is meant, we write  $\mathcal{P}^{(X)}$  where  $X$  is the random variable. An important property of a PGF is that it converges for  $|s| \leq 1$  since  $\mathcal{P}(1) = \sum_{j=0}^{\infty} p_j = 1$ . The PGF can be used to directly derive the probability function of the random variable, as well as its moments. Single probabilities can be calculated as

$$P(X = j) = p_j = (j!)^{-1} \left. \frac{d^j \mathcal{P}}{ds^j} \right|_{s=0} \quad (\text{A.3})$$

**Example:** A binomial distributed random variable has PGF  $\mathcal{P}(s) = (q+ps)^n$ . Thus,

$$\begin{aligned} P(X=0) &= \mathcal{P}(0) = q^n \\ P(X=1) &= \mathcal{P}'(0) = nq^{n-1}p \\ P(X=2) &= (2!)^{-1}\mathcal{P}''(0) = (2!)^{-1}n(n-1)q^{n-2}p^2 \\ &\vdots \quad \vdots \end{aligned}$$

The expectation  $E(X)$  satisfies the relation

$$E(X) = \sum_{j=0}^{\infty} jp_j = \mathcal{P}'(1) \quad (\text{A.4})$$

**Example:** A binomial distributed random variable has mean

$$\begin{aligned} \mathcal{P}'(1) &= np(q+p)^{n-1} \\ &= np \end{aligned}$$

Calculating first

$$E[X(X-1)] = \sum_{j=1}^{\infty} j(j-1)p_j = \mathcal{P}''(1) \quad (\text{A.5})$$

the variance is obtained as

$$\begin{aligned} \text{Var}(X) &= E[X(X-1)] + E(X) - [E(X)]^2 \\ &= \mathcal{P}''(1) + \mathcal{P}'(1) - [\mathcal{P}'(1)]^2 \end{aligned} \quad (\text{A.6})$$

**Example:** A binomial distributed random variable has variance

$$\begin{aligned} \text{Var}(X) &= n(n-1)p^2 + np - (np)^2 \\ &= np(1-p) \end{aligned}$$

**Proposition 1.** Let  $X$  be a random variable defined over the non-negative integers with probability distribution  $P(X=j) = p_j, j=0,1,\dots$ . Let  $X_T$  be a positive random variable with truncated-at-zero probability distribution  $P(X_T=j) = p_j/(1-p_0), j=1,2,\dots$ . The probability generating function of the truncated-at-zero distribution of  $X_T$  is given by

$$\mathcal{P}_T(s) = \frac{\mathcal{P}(s) - \mathcal{P}(0)}{1 - \mathcal{P}(0)} \quad (\text{A.7})$$

**Proof:** (A.7) follows directly from the definition of the probability generating function:

$$\mathcal{P}_T(s) = E(s^{X_T}) = \sum_{j=1}^{\infty} \frac{p_j}{1 - p_0} s^j$$

where  $p_0 = \mathcal{P}(0)$ .

There exists a close relationship between the probability generating function and the moment generating function  $\mathcal{M}(t)$ :

$$\mathcal{M}(t) = E(e^{tX}) = \mathcal{P}(e^t) \tag{A.8}$$

While the moment generating function is a concept that can be used for any distribution with existing moments, the probability generating function is defined for non-negative integers. Since  $s = e^t = 1$  if and only if  $t = 0$ , we obtain  $E(X) = \mathcal{P}'(1) = \mathcal{M}'(0)$ .

In the same way as in (A.1) one can define a *bivariate probability generating function*.

**Definition 2.** .

Let  $X, Y$  be a pair of integer-valued random variables with joint distribution  $P(X = j, Y = k) = p_{jk}$ ,  $j, k \in \mathbb{N}_0$ . The bivariate probability generating function is given by:

$$\mathcal{P}(s_1, s_2) = \sum_{j=0}^{\infty} \sum_{k=0}^{\infty} p_{jk} s_1^j s_2^k = E(s_1^X s_2^Y) \tag{A.9}$$

**Proposition 2.** The probability generating functions of the marginal distributions  $P(X = j)$  and  $P(Y = k)$  are  $\mathcal{P}(s, 1) = E(s^X)$  and  $\mathcal{P}(1, s) = E(s^Y)$ , respectively.

**Proposition 3.** The probability generating function of  $X + Y$  is given by  $\mathcal{P}(s, s) = E(s^{X+Y})$ .

**Proposition 4.** The variables  $X$  and  $Y$  are independent if and only if  $\mathcal{P}(s_1, s_2) = \mathcal{P}(s_1, 1)\mathcal{P}(1, s_2)$  for all  $s_1, s_2$ .

Probability generating functions can be used to establish the distribution of a sum of independent variables. This is also called a *convolution*. Using **Proposition 3** and **Proposition 4**, the probability generating function of  $Z = X + Y$  is given by:

$$\mathcal{P}^{(Z)}(s) = E(s^Z) = E(s^{X+Y}) = E(s^X s^Y) \stackrel{(*)}{=} E(s^X)E(s^Y) \tag{A.10}$$

where  $(\star)$  follows from the independence assumption.

**Example:** Let  $X$  have a binomial distribution function with  $B(1, p)$ . Consider the convolution  $Z = \underbrace{X + \dots + X}_{n\text{-times}}$ . Then:

$$\mathcal{P}^{(Z)}(s) = (q + ps)^n \tag{A.11}$$

$Z$  has a binomial distribution function  $B(n, p)$ . Conversely, the binomial distribution is obtained by a convolution of identically and independently distributed Bernoulli variables.

## B

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### Gauss-Hermite Quadrature

This appendix describes the basic steps required for a numerical evaluation of the likelihood function of count data models with unobserved heterogeneity of the log-normal type. The method is illustrated for the Poisson-log-normal model, although a similar algorithm can be used to estimate the models with endogenous selectivity presented in Chap. 5.2. Butler and Moffitt (1982) discuss Gauss-Hermite quadrature in the context of a panel probit models. Million (1998) points out that the Poisson-log-normal integral can be approximated using Gauss-Laguerre and Gauss-Legendre polynomials as well, and he evaluates the relative performance of the three methods. Crouch and Spiegelman (1990) discuss numerical integration in the related logistic-normal model.

Starting point for Gauss-Hermite quadrature is the integral

$$\int_{-\infty}^{\infty} f(y|x, \beta, \varepsilon)g(\varepsilon|\sigma^2)d\varepsilon \tag{B.1}$$

that cannot be solved by analytical methods. However, assume that by appropriate change of variable, B.1 can be brought into the form

$$\int_{-\infty}^{\infty} h(\nu; y, x, \beta, \sigma^2) \exp(-\nu^2)d\nu \tag{B.2}$$

In this case, Gauss-Hermite quadrature can be applied to numerically evaluate the integral (B.1), and thus the marginal likelihood  $L(y|x)$ . Once the evaluation has been done, the logarithm  $\ln L(y|x)$  can be passed on to a maximizer that uses numerical derivatives in order to find the maximum likelihood estimators  $\hat{\beta}$  and  $\hat{\sigma}^2$ .

The Poisson-log-normal model has the following components (see also Chap. 4.2):

$$f(y|\varepsilon) = \frac{\exp(-\exp(x'\beta + \varepsilon)) \exp(x'\beta + \varepsilon)^y}{y!}$$

where  $\varepsilon \sim N(0, \sigma^2)$ , i.e.,

$$f(\varepsilon) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{\varepsilon}{\sigma}\right)^2}$$

Change of variable from  $\varepsilon$  to  $\nu$  where

$$\nu = \frac{\varepsilon}{\sqrt{2}\sigma}$$

has inverse  $\varepsilon = \nu\sqrt{2}\sigma$  and Jacobian  $df(\nu)/d\nu = \sqrt{2}\sigma$ . Therefore

$$g(\nu) = \frac{1}{\sqrt{\pi}} e^{-\nu^2}$$

and

$$f(y|\nu)g(\nu) = \frac{\exp(-\exp(x'\beta + \nu\sqrt{2}\sigma)) \exp(x'\beta + \nu\sqrt{2}\sigma)^y}{\sqrt{\pi}y!} e^{-\nu^2}$$

Let

$$h_i(\nu) = \frac{\exp(-\exp(x'_i\beta + \nu\sqrt{2}\sigma)) \exp(x'_i\beta + \nu\sqrt{2}\sigma)^{y_i}}{\sqrt{\pi}y_i!}$$

where the subscript  $i$  reminds us that this function depends on observations  $y_i$  and  $x_i$ . Then the Gauss-Hermite approximation to the integral B.1 is obtained as

$$\begin{aligned} L_i^{gh} &= \int_{-\infty}^{\infty} h_i(\nu) \exp(-\nu^2) d\nu \\ &\approx \sum_{j=1}^n w_j h_i(\nu_j) \end{aligned}$$

where  $w_j$  are weights and  $\nu_j$  are the evaluation points. The likelihood function for  $n$  independent observations is given by

$$L^{gh} = \prod_{i=1}^n \sum_{j=1}^n w_j h_i(\nu_j)$$

Weight factors and abscissas for 20-point quadrature are given in Tab. B.1 (Source: Abramowitz and Stegun, 1964, p. 924).

**Table B.1.** Abcissas and Weight Factors for 20-point Gauss-Hermite Integration

$u_i$	$w_i$
-5.3874809	2.2939000e-13
-4.6036824	4.3993400e-10
-3.9447640	1.0860000e-07
-3.3478546	7.8025500e-06
-2.7888061	0.00022833863
-2.2549740	0.0033243773
-1.7385377	0.024810521
-1.2340762	0.10901721
-0.73747373	0.28667551
-0.24534071	0.46224367
0.24534071	0.46224367
0.73747373	0.28667551
1.2340762	0.10901721
1.7385377	0.024810521
2.2549740	0.0033243773
2.7888061	0.00022833863
3.3478546	7.8025500e-06
3.9447640	1.0860000e-07
4.6036824	4.3993400e-10
5.3874809	2.2939000e-13

Source: Abramowitz and Stegun, 1964, p. 924

# C

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## Software

Most statistical and econometric software distributions contain built-in procedures for standard count data models, such as the Poisson and the negative binomial regression models. Development in the software sector is fast, and specific recommendations risk to become outdated very quickly. Nevertheless, there are a few general points that should be of help to anyone interested in working with count data and estimating the models presented in this book.

Within the econometrics research community, GAUSS traditionally has been the major development tool. GAUSS is mostly a programming environment, but specialised procedures are available both as part of the general distribution, and through web sites and mailing lists. For example, the “count” module allows the estimation of seemingly unrelated regression models, of various types of negative binomial models as well as hurdle Poisson models. Yet, the development of this module has stalled for some time, and the latest models are not available.

Two alternative programs with a much more ambitious offering in this area are STATA and LIMDEP. This appendix is not intended as a comprehensive review of available software for count data, and there may be other software with similar or even broader scope. Yet, the possibilities that these two packages offers should be closely scrutinized by anyone seriously interested in count data applications who wants to apply up-to-date methods without doing the programming for herself. In fact, most of the models discussed in this book are easily estimated with STATA or LIMDEP, providing little support for those who resort to the most basic models in want of available software for the more appropriate ones.

The following short summary refers to STATA release 7.0. This release includes built-in procedures, apart from the standard Poisson and Negbin models (in its various parameterizations, as Negbin I, Negbin II or with more flexible variance function), for zero-inflated Poisson and zero-inflated negative binomial models, and for fixed and random effects panel count data models. Random effects models include the negative binomial panel model (with fixed or random effects) but also the panel Poisson-log-normal model. This proce-



dures can also be used in cross sections to estimate the standard Poisson-log-normal model that frequently has a better fit than the Negbin model. Hurdle Poisson or negative binomial models are not included in the standard distribution. However, they can be estimated using routines on truncated-at-zero models authored by Joseph Hilbe and described in the *Stata Technical Bulletin* Nr. 47. Most procedures include options for the computations of robust standard errors (to perform pseudo maximum likelihood estimation) as well as account for clustered sampling.

The latest version of LIMDEP is release 8.0. Apart from the standard count data models, its capabilities include the estimation of sample selection models by maximum likelihood, parametric models for underreporting where the observed counts represent only the reported fraction of the total events which have occurred, and maximum likelihood estimation of various types of hurdle models and zero-inflated models. LIMDEP and STATA are both quite versatile in the area of count data modelling.

# D

## Tables

**Table D.1.** Number of Job Changes: Poisson and Poisson-Log-Normal

	Poisson	Poisson-log-normal	Mean
Constant	0.501** (0.158)	0.072 (0.227)	1
Education*10 <sup>-1</sup>	-0.138 (0.137)	-0.120 (0.187)	1.216
Experience*10 <sup>-1</sup>	-0.770** (0.111)	-0.846** (0.155)	1.460
Experience <sup>2</sup> * 10 <sup>-2</sup>	0.119** (0.037)	0.127* (0.050)	2.943
Union	-0.292** (0.065)	-0.324** (0.088)	0.429
Single	-0.050 (0.108)	-0.093 (0.153)	0.077
German	-0.368** (0.076)	-0.390** (0.104)	0.668
Qualified White Collar	0.067 (0.131)	-0.002 (0.179)	0.137
Ordinary White Collar	0.185 (0.147)	0.190 (0.207)	0.058
Qualified Blue Collar	0.147 (0.082)	0.112 (0.114)	0.501
$\sigma^2$		1.048** (0.048)	
Log likelihood	-2044.47	-1866.80	
Log likelihood ( $\beta_1, \dots, \beta_9 = 0$ )	-2155.40	-1934.53	
Number of Observations	1962		

Source: *German Socio-Economic Panel*, Wave A/1984; own calculations.

Note: Asymptotic standard errors in parentheses.

**Table D.2.** Number of Job Changes: Negative Binomial Models

	Negbin I	Negbin II	$GEC_k$
Constant	0.341 (0.191)	0.616** (0.224)	0.380 (0.212)
Education* $10^{-1}$	0.008 (0.162)	-0.179 (0.187)	-0.011 (0.180)
Experience* $10^{-1}$	-0.762** (0.139)	-0.786** (0.152)	-0.775** (0.144)
Experience <sup>2</sup> * $10^{-2}$	0.113* (0.046)	0.118* (0.048)	0.115* (0.047)
Union	-0.274** (0.080)	-0.308** (0.087)	-0.283** (0.084)
Single	-0.114 (0.139)	-0.054 (0.152)	-0.108 (0.141)
German	-0.316** (0.097)	-0.404** (0.102)	-0.331** (0.103)
Qualified White Collar	-0.022 (0.163)	0.043 (0.174)	-0.013 (0.173)
Ordinary White Collar	0.213 (0.176)	0.188 (0.201)	0.214 (0.181)
Qualified Blue Collar	0.086 (0.103)	0.132 (0.111)	0.094 (0.107)
$\sigma^2$	0.823** (0.088)	1.378** (0.137)	0.892** (0.080)
$k$			0.139 (0.281)
Log likelihood	-1873.28	-1878.63	-1873.17
Number of Observations	1962		

Source: *German Socio-Economic Panel*, Wave A/1984; own calculations.

Notes: Asymptotic standard errors in parentheses. For  $\sigma^2 > 0$  and  $k = 0$ , the  $GEC_k$  model coincides with the Negbin I model. For  $\sigma^2 > 0$  and  $k = 1$ , the  $GEC_k$  model coincides with the Negbin II model.

**Table D.3.** Number of Job Changes: Robust Poisson Regression

	Coefficient	$t_{\text{Poisson}}$	Robust $t$ -Values		
			$t_{\text{WHITE}}$	$t_{\text{LVF}}$	$t_{\text{QVF}}$
Constant	0.501	3.167	2.617	2.229	2.304
Education* $10^{-1}$	-0.138	-1.006	-0.823	-0.707	-0.749
Experience* $10^{-1}$	-0.770	-6.929	-4.830	-4.877	-5.055
Experience <sup>2</sup> * $10^{-2}$	0.119	3.269	2.385	2.301	2.486
Union	-0.292	-4.499	-3.115	-3.167	-3.385
Single	-0.050	-0.460	-0.309	-0.323	-0.326
German	-0.368	-4.843	-2.892	-3.409	-3.503
Qualified White Collar	0.067	0.514	0.343	0.361	0.384
Ordinary White Collar	0.185	1.255	0.964	0.883	0.917
Qualified Blue Collar	0.147	1.794	1.261	1.263	1.308
Log likelihood	-2044.47				
Number of Observations	1962				

**Notes:**

Three alternative methods to calculate robust standard errors (and thus robust  $t$ -values) were given in Chap. 3.3.3.  $t_{\text{LVF}}$  and  $t_{\text{QVF}}$  are based on the assumption of a quadratic and linear variance function, respectively, while the White method makes no explicit assumption.

**Table D.4.** Number of Job Changes: Poisson-Logistic Regression

Variable	<b>a) Overlapping</b>		<b>b) Non Overlapping</b>	
	Offers	Acceptance	Offers	Acceptance
Constant	0.812 ( 3.746)		1.151 ( 9.740)	
Education*10 <sup>-1</sup>	-0.322 -2.073)	3.732 ( 1.582)		-0.260 (-1.633)
Experience*10 <sup>-1</sup>	-0.668 (-4.804)	-6.044 (-1.221)		-1.068 (-7.678)
Experience <sup>2</sup> * 10 <sup>-2</sup>	0.071 ( 1.382)	3.321 ( 1.132)		0.175 ( 3.920)
Union	-0.291 (-4.477)		-0.290 (-4.470)	
Single		0.379 ( 0.153)		-0.068 (-0.460)
German	-0.397 (-5.112)		-0.355 (-4.708)	
Qualified White Collar	0.069 ( 0.452)		0.088 ( 0.684)	
Ordinary White Collar	0.178 ( 1.125)		0.195 ( 1.328)	
Qualified Blue Collar	0.132 ( 1.389)		0.156 ( 1.919)	
Log likelihood	-2039.35		-2043.88	
Observations	1962			

**Notes:**Asymptotic *t*-values in parentheses.

**Table D.5.** Number of Job Changes: Hurdle Count Data Models

Variable	Hurdle Poisson		Probit-Poisson-log-normal	
	1+/0	1+	1+/0	1+
Constant	-0.069 (0.202)	1.163 (0.245)	0.269 (0.157)	0.799 (0.666)
Education*10 <sup>-1</sup>	0.133 (0.170)	-0.600** (0.218)	0.094 (0.128)	-0.764** (0.324)
Experience*10 <sup>-1</sup>	-0.758** (0.148)	-0.403** (0.156)	-0.629** (0.111)	-0.544 (0.405)
Experience <sup>2</sup> * 10 <sup>-2</sup>	0.107** (0.048)	0.085 (0.050)	0.098** (0.034)	0.103 (0.088)
Union	-0.268** (0.084)	-0.167* (0.097)	-0.205** (0.061)	-0.230 (0.189)
Single	-0.194 (0.149)	0.192 (0.147)	-0.149 (0.114)	0.195 (0.249)
German	-0.330** (0.101)	-0.206** (0.108)	-0.254** (0.076)	-0.223 (0.208)
Qualified White Collar	-0.071 (0.170)	0.271 (0.196)	-0.076 (0.125)	0.283 (0.285)
Ordinary White Collar	0.239 (0.185)	-0.039 (0.236)	0.200 (0.143)	-0.057 (0.336)
Qualified Blue Collar	0.069 (0.109)	0.184 (0.117)	0.042 (0.081)	0.167 (0.172)
$\sigma^2$			0.932** (0.156)	
$\rho$			0.212 (0.893)	
Log-likelihood	-1928.00		-1856.70	
Observations	1962			

**Notes:**

Asymptotic standard errors in parentheses.

Hurdle negbin results are not displayed because of convergence problems.

**Table D.6.** Number of Job Changes: Finite Mixture Models

Variable	2-components Poisson		2-components Negbin II	
	group 1	group 2	group 1	group 2
Constant	-0.000 (0.226)	2.229** (0.433)	1.047* (0.630)	0.154 (0.458)
Education*10 <sup>-1</sup>	0.078 (0.184)	-0.368 (0.374)	-0.648 (0.425)	0.243 (0.307)
Experience*10 <sup>-1</sup>	-0.857** (0.172)	-0.541** (0.231)	-0.371 (0.346)	-1.140** (0.296)
Experience <sup>2</sup> * 10 <sup>-2</sup>	0.104* (0.060)	0.081 (0.074)	0.050 (0.099)	0.138 (0.105)
Union	-0.309** (0.095)	-0.207 (0.141)	-0.259 (0.181)	-0.328** (0.152)
Single	-0.156 (0.158)	0.057 (0.229)	0.200 (0.325)	-0.274 (0.267)
German	-0.351** (0.114)	-0.478** (0.158)	-0.609** (0.236)	-0.101 (0.229)
Qualified White Collar	-0.037 (0.192)	0.168 (0.288)	0.320 (0.386)	-0.263 (0.327)
Ordinary White Collar	0.253 (0.202)	0.103 (0.358)	-1.037 (0.945)	0.609* (0.353)
Qualified Blue Collar	0.082 (0.124)	0.317* (0.173)	0.393 (0.263)	-0.130 (0.224)
$\sigma^2$			2.096** (0.949)	0.146 (0.281)
$\pi_1$	0.930** (0.013)		0.395** (0.158)	
Log-likelihood	-1868.16		-1856.05	
Observations	1962			

**Notes:**

Asymptotic standard errors in parentheses.

Hurdle Negbin I results are not displayed because of convergence problems.

**Table D.7.** Number of Job Changes: Zero Inflated Count Data Models

Variable	zero-inflated Poisson		zero-inflated Negbin II	
	logit	Poisson	logit	Negbin II
Constant	1.132 (0.245)	-0.303 (0.529)	0.483* (0.255)	-7.390** (2.777)
Education*10 <sup>-1</sup>	-0.583** (0.203)	1.016** (0.455)	-0.262 (0.216)	-0.746 (1.152)
Experience*10 <sup>-1</sup>	-0.373** (0.153)	1.035** (0.312)	-0.613** (0.192)	4.535** (1.715)
Experience <sup>2</sup> * 10 <sup>-2</sup>	0.072 (0.049)	-0.157 (0.091)	0.129** (0.062)	-.759** (0.346)
Union	-0.158 (0.097)	0.293 (0.179)	-0.253** (0.102)	0.351 (0.465)
Single	0.151 (0.154)	0.461 (0.297)	0.066 (0.169)	1.368 (0.962)
German	-0.173 (0.106)	0.435** (0.211)	-0.236** (0.118)	1.306 (0.788)
Qualified White Collar	0.272 (0.189)	0.519 (0.354)	0.178 (0.206)	1.228 (0.843)
Ordinary White Collar	-0.123 (0.243)	-0.870 (0.711)	0.025 (0.203)	11.967 (349.869)
Qualified Blue Collar	0.166 (0.115)	0.094 (0.219)	0.151 (0.129)	0.193 (0.614)
$\sigma^2$			1.103 (0.146)	
Log-likelihood	-1926.28		-1866.73	
Observations	1962			

**Notes:**

Asymptotic standard errors in parentheses.



**Table D.8.** Number of Job Changes: Quantile Regressions

	$Q_z(0.5, x)$	$Q_z(0.75, x)$	$Q_z(0.9, x)$
Constant	-0.181 (0.468)	1.138 (0.475)	1.768 (0.272)
Education*10 <sup>-1</sup>	0.319 (0.373)	0.026 (0.343)	-0.343 (0.207)
Experience*10 <sup>-1</sup>	-1.346 (0.249)	-1.413 (0.258)	-0.721 (0.196)
Experience <sup>2</sup> * 10 <sup>-2</sup>	0.288 (0.069)	0.220 (0.083)	0.066 (0.054)
Union	-0.388 (0.193)	-0.395 (0.187)	-0.336 (0.117)
Single	-0.469 (0.324)	-0.191 (0.248)	-0.128 (0.220)
German	-0.479 (0.246)	-0.522 (0.213)	-0.209 (0.162)
Qualified White Collar	-0.144 (0.304)	-0.063 (0.302)	-0.020 (0.237)
Ordinary White Collar	0.240 (0.319)	0.312 (0.340)	-0.061 (0.188)
Qualified Blue Collar	-0.142 (0.212)	-0.078 (0.179)	-0.082 (0.137)
Observations	1962		

**Notes:**

Bootstrap standard errors in parentheses (50 replications).

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## Author's Index

- Abramowitz 17, 57, 287  
Aitchison 134, 214  
Aitkin 254  
Al-Osh 232, 235  
Al-Qudsi 257  
Albert 242  
Alfo 141  
Allison 50  
Alvarez 119  
Alzaid 232, 235  
Anderson 260  
Andrews 120  
Angrist 160, 166  
Arulampalam 179  
Atella 259, 260
- Böckenholt 142, 233, 239  
Böhning 254  
Börsch-Supan 261, 263, 270  
Bago d'Uva 187  
Balakrishnan 152  
Barlow 54, 55  
Barnby 74, 75, 254, 255  
Barron 232  
Bates 18, 20  
Bauer 74, 252  
Becker 262  
Beckmann 189  
Behringer 265  
Berglund 194  
Berkhout 207  
Blundell 221, 223, 226, 230, 232  
Boes 68
- Booth 179  
Borjas 18  
Bortkiewicz 251  
Bourlange 94  
Bowman 57  
Bowyer 261  
Brännäs 94, 130, 140, 146, 194, 229,  
232–234, 237  
Bradlow 50  
Breslow 92  
Brockett 260  
Broek, van den 117  
Buck 232  
Burkhauser 265  
Butler 285
- Cameron 21, 47, 48, 63, 93, 102, 107,  
116, 118, 119, 134, 223, 226, 255,  
256  
Carson 144, 145  
Caudill 147, 257, 258  
Chamberlain 230  
Chatfield 27  
Chernoff 113  
Chesher 118  
Chib 134, 205, 210, 243, 245, 247, 248,  
254  
Chung 212  
Cincera 221  
Cockburn 142  
Consul 33, 46, 47  
Covas 190, 258  
Cox 17, 54, 55, 122  
Crépon 110, 153, 154, 190, 221, 230

- Cramer 80  
 Creel 144, 178, 253  
 Crouch 285
- Davidson 100, 163  
 Davutyan 3, 232, 260  
 Dean 102, 131, 132  
 Deb 142, 149, 150, 169, 186  
 DeGroot 22  
 Delgado 95–97, 119  
 DeSarbo 260  
 Dey 212  
 Diggle 74, 156, 220, 254  
 Dillon 260  
 Dionne 3, 119, 120, 252  
 Dong 136  
 Doornik 254  
 Doorslaer 187, 255  
 Doz 94  
 Duguet 110, 153, 154, 190, 221, 230  
 Duijn, van 142
- Ebmer 264  
 Efron 49  
 Ehrenberg 27  
 Elder 204, 210, 216, 255, 256  
 Elias 179  
 Engle 158, 167  
 Englin 146  
 Evans 168, 251
- Faddy 14, 39  
 Famoye 46, 258, 259  
 Feinstein 252  
 Feller 16, 17, 20, 37, 54, 55, 75, 195, 281  
 Firth 86, 87, 232  
 Flowerdew 254  
 Freund 156, 255–257
- Gagné 3  
 Gallant 47  
 Gameraen 255, 256  
 Gameraen 245  
 Ganio 102  
 Geil 221, 255  
 Gentle 237  
 Gerdtham 255  
 Gilbert 63, 119  
 Goldberger 71
- Golden 260  
 Gomez 136, 210, 253  
 Good 214  
 Goodhardt 27  
 Gourieroux 41, 42, 89, 93, 105, 110, 122, 124, 154, 217, 218  
 Graham 251  
 Greenberg 205, 243, 245, 248, 254  
 Greene 154, 156, 228, 248, 261  
 Greenwood 131  
 Griffith 221, 223, 226, 230, 232  
 Griliches 63, 134, 211–213, 221, 224, 227, 229  
 Grogger 144, 145, 164, 252  
 Grootendorst 184, 189, 255  
 Guldberg 26  
 Guo 47, 105–107, 131, 132, 138  
 Gupta 260  
 Gurmu 30, 117, 130, 138, 139, 144, 179, 184, 204, 210, 216, 253, 255, 256
- Haab 253  
 Hahn 251  
 Hall 63, 134, 211–213, 221, 224, 227, 229, 261  
 Hansen 99, 100  
 Harris 260  
 Hastie 103  
 Hausman 63, 112, 124, 125, 134, 211–213, 221, 224, 227, 229  
 Heckman 18, 59, 139, 149, 152  
 Hellström 232  
 Hendry 158, 167  
 Hernandez 171  
 Hinde 124, 133  
 Hinkley 10  
 Ho 134, 214
- Jaggia 261  
 Jensen 255  
 Jiménez-Martin 186, 255  
 Johansson 47, 48, 229, 234  
 Johnson 16, 18, 20, 26–28, 40, 41, 109, 130, 145, 152  
 Jones 187, 255  
 Jorgensen 254  
 Jovanovic 262, 263  
 Jung 204, 210, 233, 235, 237, 261, 262
- Kahn 189, 251



- Kalwij 258, 259  
 Karlis 130  
 Kelly 252  
 Kenkel 103, 254  
 Kennan 2, 144, 237  
 Kennedy 71, 237  
 King 26, 45, 66, 67, 111, 210  
 Kniesner 95, 97, 156  
 Knuth 94, 246  
 Kocherlakota 27, 205, 209  
 Koolman 187, 255  
 Kotz 16, 18, 20, 26–28, 40, 41, 109, 130,  
 145, 152  
 Kozumi 169  
 Kulasekera 41
- Labeaga 186, 255  
 Laird 140  
 Lakshminarayana 205  
 Lambert 109, 110, 189  
 Lancaster 50, 54, 62  
 Lawless 102, 113, 131, 132, 134, 135  
 Lazear 262  
 Lee 50, 118, 149, 150, 215  
 Lerman 145  
 Li 105–107  
 Liang 74, 156, 220, 254  
 Liesenfeld 233  
 List 189  
 Long 261  
 Loomis 144, 178, 253  
 LoSasso 156
- Møller Danø 255  
 Maasoumi 84  
 Machado 199  
 MacKinnon 163  
 Maddala 151  
 Manski 145  
 Marshall 213  
 Martinez-Granado 187, 255  
 Mayer 257, 259  
 McConnell 253  
 McCullagh 2, 42, 74, 86, 92, 119, 234  
 McIntosh 147, 257, 258  
 McKelvey 68  
 McKenzie 235, 237  
 McKinnon 100  
 Melkersson 32, 190, 255, 258, 259
- Merkle 31, 264  
 Michener 251  
 Million 205, 256, 285  
 Mincer 262, 263  
 Miranda 202  
 Mixon 147, 257, 258  
 Moffatt 118, 147, 254  
 Moffitt 285  
 Monfort 41, 42, 89, 93, 122, 124, 154,  
 217, 218  
 Montalvo 221, 230  
 Mortensen 197  
 Mroz 141, 150, 171  
 Mukhopadhyay 109  
 Mullahy 72, 108, 109, 121, 157, 160,  
 162, 163, 166, 178–180, 189, 254,  
 256  
 Munkin 213, 215  
 Murphy 156
- Nakamura 107  
 Nelder 2, 42, 74, 86, 92, 119, 234  
 Neyman 18, 20  
 Nguyen-Dinh 257  
 Nolan 74, 75, 255  
 Nourse 254  
 Nychka 47
- Okoruwa 254  
 Olkin 213  
 Olsson 255  
 Ophem, van 171, 216  
 Ozuna 136, 210, 253
- Pandit 205  
 Panjer 260  
 Pepple 242  
 Pesaran 120  
 Peters 147, 254  
 Pirog-Good 214  
 Plassmann 247, 252  
 Plug 207  
 Pohlmeier 179, 183, 186, 255, 256  
 Portney 166, 254, 256  
 Praag, van 109, 196, 197  
 Prieger 172, 251  
 Proschan 54, 55  
 Puterman 142
- Ramaswamy 260

- Rao 205  
 Reid 10  
 Richard 158, 167  
 Rilstone 130, 138, 139, 216  
 Riphahn 205, 256, 257, 259  
 Robin 260  
 Romeu 47, 150, 171  
 Ronning 233, 235, 237  
 Rooth 32  
 Rosati 259, 260  
 Rose 74, 204, 251  
 Rosenqvist 130, 140  
 Roth 190, 258, 259  
 Roy 161  
 Ruser 136, 252
- Saha 136  
 Sander 166  
 Santos Silva 36, 37, 46, 99, 108, 112,  
 137, 145, 146, 160, 161, 163, 164,  
 185, 190, 193, 199, 256, 258  
 Sapra 103  
 Schellhorn 162, 255, 257  
 Schwab 168  
 Schwalbach 3  
 Shafer 102  
 Shaked 175  
 Shaw 145, 253  
 Shenton 57  
 Shonkwiler 146, 253, 260  
 Signorino 26  
 Silcock 261  
 Simar 140  
 Singer 59, 139  
 Smith 254  
 Spiegelman 285  
 Srivastava 41  
 Stegun 17, 57, 287  
 Stern 130, 138, 139, 216
- Terza 108, 143, 146, 147, 149, 152, 167,  
 168, 254  
 Terza 103  
 Thosar 261  
 Tibshirani 103  
 Tideman 247, 252  
 Tighe 251  
 Tomlin 189  
 Tonkyn 41
- Topel 156, 261, 262  
 Trivedi 21, 47, 63, 93, 102, 107, 109,  
 116–118, 131, 132, 134, 138, 142,  
 150, 169, 179, 186, 213, 215, 223,  
 226, 253  
 Trivedi, 149  
 Trognon 42, 89, 93, 217, 218  
 Trovato 141
- Ulrich 179, 183, 186, 255, 256
- Van Ophem 150  
 van Reenen 221, 230  
 Vanasse 3, 119, 120, 252  
 Veall 119  
 Vera-Hernandez 47, 150, 162, 255  
 Vermeulen 109, 196, 197  
 Visser 105, 110  
 Vistnes 255  
 Vuong 112, 120, 122, 123, 184, 185, 273  
 Vuong test 274
- Wagner 265  
 Wambach 205, 256  
 Wang 46, 141, 142, 258, 259  
 Ward 261, 262  
 Wedel 141, 142, 260  
 Weiss 149, 215  
 White 87, 92, 117  
 Williams 123, 124  
 Willmot 131, 132  
 Wilson 179  
 Windmeijer 36, 37, 99, 108, 119, 137,  
 160, 161, 163, 164, 193, 223, 226,  
 230, 232, 256  
 Winkelmann 3, 22, 26, 50, 68, 71, 74,  
 75, 94, 107–109, 111, 134, 136, 149,  
 154, 177, 184, 186, 187, 193, 194,  
 197, 198, 202, 204, 205, 210, 221,  
 243, 245, 247, 248, 254, 255, 257,  
 259, 261, 262  
 Woittiez 255, 256  
 Wooldridge 103, 128, 166, 232  
 Wun 234
- Xekalaki 130
- Yen 254  
 Yousry 41

Yule 131

Zavoina 68

Zeger 74, 156, 220, 229, 232–234, 254

Zellner 210, 241

Zimmer 150

Zimmermann 3, 22, 31, 75, 94, 109,  
111, 119, 136, 194, 197, 199, 257,  
259, 261, 264

---

## Subject Index

- airline accidents 3, 251
- auxiliary regression 93, 118
- average partial effects 128
- Bayesian estimation
  - approximation 242
  - conjugate prior 242
  - Gibbs sampling 246
  - inequality constraints 244
  - joint posterior 247, 249
  - Markov Chain Monte Carlo 248
  - Metropolis-Hastings 243
  - multivariate Poisson model 247
  - Poisson model with underreporting 245
  - Poisson regression 242
  - posterior simulation 243
  - prior distribution 243, 247
  - random coefficients model 248
- bias correction 87
- binary endogenous variable 162, 165, 167
  - maximum likelihood 168
  - moment estimator 170
- binomial distribution 15, 18, 28, 194
  - continuous parameter 25
  - displaced 236
  - Katz system 40
  - mean 25, 26
  - probability function 25
  - probability generating function 25, 281
  - variance 25
- binomial thinning 235
- bivariate negative binomial model 213
- bivariate normal distribution 149, 150, 168
  - conditional mean 151
- bivariate Poisson distribution
  - convolution structure 205
  - covariance matrix 206
  - linear regression 207
  - non-negative correlation 210
  - one-factor 206
  - overdispersion 211
  - parameterization 210
  - probability generating function 207
  - trivariate reduction 205
- blockage time 75
- ceiling function 26
- censoring 31, 108, 143, 146
  - endogenous 153
  - incomplete fertility 147
  - right 146
- change of variable 104
- chi-squared distribution 114
- compounding 36, 193
- consumer purchase 196
- consumer surplus 253
- convolution 37, 284
- corner solution outcomes 173, 189
- corrected score 106
- count process 7, 16
- Cramér-Rao lower bound 80
- credit card default 156
- delta rule 114, 270

- deviance 119, 120
- differences in differences 71
- dispersion parameter 152
- displaced binomial distribution 236
- doctor consultations 255
- double hurdle model 181
- double Poisson 49
- drug utilization 189
- duration dependence 17, 18, 53, 55, 107
- dynamic panel models 230
  
- efficient estimation 130
- elasticity 70
- EM algorithm 133
- endogeneity 156
  - additive error 164
  - exposure time 75
  - instrumental variables 162
  - multiplicative error 163
  - non-random selection 149
  - panel data 221
  - sampling 144
  - stratification 145
- endogenous switching 152
- equidispersion 8
- Erlang distribution 17, 52, 54, 76
- estimation in stages 160, 165
- excess zeros 109, 173, 180, 188
  - in hurdle model 178
- exclusion restriction 165
- exogeneity 156-160
  - strict 225
  - tests for 156
  - weak 230
- exponential distribution 53
  - Laplace transform 17
- exposure time 74
- extensive margin 176, 177, 192
  
- fertility 3, 75, 147, 190, 257
- finite mixture 140, 142, 186
- Fisher information 80
- forbidden regression 167
  
- gamma count distribution 59
- gamma distribution 56, 107, 130, 131, 242
- gamma function 20, 22
  
- incomplete 57
- Gauss-Hermite quadrature 133, 154, 155, 198, 285
  - abscissas and weight factors 287
- generalized additive models 103
- generalized method of moments 99
- geometric distribution 22, 42
- German Socio-Economic Panel 261
- Gibbs sampling 246
  - full conditionals 246
- gradient 78
- gravity model 254
  
- Hausman test 124
- hazard function 52
  - constant 53
  - decreasing 56
  - increasing 56
  - unobserved heterogeneity 61
- Hessian matrix 78, 83, 195
- heteroskedasticity 66, 69, 92
- hurdle model 178
  - at zero 181
  - excess zeros 178
  - extensive margin 182
  - identification 183
  - intensive margin 182
  - logit model 184
  - marginal effects 182
  - marginal probability effects 182
  - mean 179
  - negative binomial 181
  - overdispersion 180
  - parent model 179
  - Poisson distribution 180, 181
  - Poisson-log-normal 187
  - probit hurdle 187
  - selection variable 178
  - separable log-likelihood 181
  - truncation 179
  - underdispersion 179, 180
  - variance 180
- hypergeometric distribution 19
  
- identification
  - in hurdle negative binomial model 183
  - in Poisson-logistic model 195
- INAR process 235

- incidental censoring 148
- individual random effect 221, 222
- information matrix 135
  - equality 117
  - test 117
- innovation process 235
- instrumental variables 162
  - additive 164
  - multiplicative 163
- insurance claims 197
- intensive margin 176, 177, 192
- interactive effects 71
- interarrival time 16
- inverse Gaussian distribution 130, 132
- inverse Mills ratio 156
  
- job changes 193, 210
- job offers 197, 264
  
- Katz family 40
  - test of Poisson against 115
  
- labor mobility 261
- Lagrange multiplier test 113, 114
  - information matrix test 118
  - Poisson vs Katz 115
  - zero inflation 117
- Laguerre polynomial 130, 139
- Laplace transform 17
  - exponential distribution 17
  - gamma distribution 17
- latent class model 186
- law of iterated expectation 34
- likelihood ratio test 113, 273
- linear exponential family 42
  - natural parameter 43
  - variance 43
- log-linear model 66
- log-normal distribution 130, 151
  - censored mean 151, 155, 169
  - mean 132
  - variance 132
- logarithmic distribution 137, 193
  - compounding 27
  - overdispersion 27
  - probability function 27
  - probability generating function 27
  - underdispersion 27
- logarithmic offset 74, 251, 258
  
- logit model 184, 194
  
- marginal effects 70
  - hurdle model 182
  - zero-inflated Poisson model 191, 192
- marginal probability effects 73, 182, 199
- marketing research 142, 260
- Markov chain Monte Carlo 215, 248
- Markov process 236
- maximum likelihood 77
  - constant-only Poisson model 82
  - large sample properties 80
  - Newton-Raphson 78
  - Poisson regression model 77
  - variance estimator 82
- measurement error 105
  - corrected score 106
- Metropolis-Hastings algorithm 243, 250
  - probability of move 243
  - proposal density 243
  - tailored proposal 243
- mixture 33
  - finite 142
  - multivariate 214
- moment conditions 99, 160, 165
- moment generating function 130, 139, 283
- Monte Carlo 87
- multi-episode model 193
- multi-index models 177
- multinomial distribution 225
- multinomial logit model 276
- multivariate models
  - correlation structure 203
  - latent Poisson-normal model 216
  - multivariate mixing 214
  - multivariate negative binomial 210
  - negative correlation 214, 217
  - panel data 204
  - parameter heterogeneity 205
  - Poisson model 205
  - Poisson-gamma mixture 212
  - Poisson-log-normal model 213
  - seemingly unrelated 204
  - semiparametric 216, 217

- negative binomial distribution 18, 20, 21, 28, 131, 146
  - convergence to Poisson 23
  - convolution 24, 210, 227
  - expression for Gamma ratio 22
  - hyper-Negbin 41
  - Katz system 40
  - mean 21
  - Negbin I 21, 24
  - Negbin II 21, 35
  - Negbin<sub>k</sub> 22
  - Poisson gamma mixture 24
  - probability function 20
  - probability generating function 20
  - shifted 41
  - variance 21
- negative binomial regression 134, 264
  - fixed effects 227
  - hurdle model 181, 183, 185
  - information matrix 135
  - log-likelihood function 135
  - Negbin I 136
  - Negbin II 136
  - Negbin<sub>k</sub> 124, 136, 137
  - Negbin<sub>X</sub> 137
  - random effects 229
  - test for Negbin I vs Negbin II 136
  - zero-inflation 188
- Negbin<sub>X</sub> 137
- Newton-Raphson algorithm 78
- non-linear instrumental variables 160
- non-linear least squares 67, 98
- non-nested models 124, 184
  - simulation-based tests 123
  - Vuong test 122
- non-parametric models 48, 95
- non-random selection 149
- non-stationarity 14
- normal distribution
  - moment generating function 151
- number of unemployment spells 143, 172, 197, 264, 265
- numerical derivatives 79
- occurrence dependence 14, 17, 18
- offer arrivals 264
- omitted variables 134, 156
- on-site sampling 144, 253
- ordered logit 68
- ordered probit 68
- overdispersion 8, 21, 45, 48, 59, 91, 129, 180
  - and mixing 35
  - Katz system 41
- overlapping models 184
- overparameterization 152
- Pòlya-Eggenberger distribution 18
- panel data 130, 206, 229
- panel data models
  - conditional likelihood 225, 227
  - dynamic models 230
  - fixed effects 222
  - fixed effects Poisson 222
  - mean scaling model 226
  - negative binomial 227
  - Negbin-beta 229
  - random effects 229
  - robust estimation 226
  - semiparametric 229
- parametric restrictions 136
- Pareto distribution 41
- Pascal distribution 22
- patents 3, 110, 154, 221
- Pearson statistic 119
- physician services 186
- Poisson distribution 10, 14, 16–18, 28, 42, 57, 93, 180
  - and exponential distribution 9
  - Bernoulli compounding 38
  - binomial limit 15
  - bivariate 205, 209
  - compounding 37
  - convolution 9
  - derivative of probability function 9
  - displaced 10, 145
  - expected value 8
  - exponential interarrival times 11, 16
  - Gamma mixture 35
  - generalizations 33
  - generalized Poisson distribution 46, 47, 258
  - genesis of 10
  - Katz system 40
  - linear transformation 10
  - mixture 45, 130
  - on-site 145
  - probability function 7

- probability generating function 8, 281
- recursive probabilities 8
- shifted 145
- size-biased 145
- truncation 31
- unobserved heterogeneity 36, 103, 127
- variance 8
- zero and two inflation 32
- zero inflation 32, 110, 188
- Poisson process 7
  - bivariate 209
  - univariate 11
- Poisson regression 1, 63, 87, 120
  - Bayesian analysis 241, 240
  - bias of OLS 67
  - bias reduction 84
  - bivariate 108, 203
  - constant-only Poisson model 82
  - compound 194
  - dummy regressor 71
  - elasticity 70
  - endogeneity 108, 156
  - endogenous truncation 155
  - finite mixture 139
  - generalized 46
  - grouped 147
  - hurdle model 180
  - logarithmic offset 74, 251
  - marginal effects 70
  - marginal probability effects 73, 182, 274
  - maximum likelihood 77
  - mean function 2, 64, 102
  - measurement error 105
  - misspecification 102
  - multivariate 203
  - non-linear least squares 67
  - random effects 229
  - risk period 74, 75
  - robust 91
  - seemingly unrelated 210
  - unobserved heterogeneity 19, 36, 103, 104, 127-129, 159-161
  - underreporting 109, 194, 196
  - variance function 64
  - zero-inflation 110, 188
- Poisson-binomial mixture 196, 237
- Poisson-log-normal model 133, 134
  - Gauss-Hermite quadrature 285
  - multivariate 213
- Poisson-logistic model 194, 198
  - identification 195
- polynomial expansion 48, 281
- posterior distribution 241
- probability generating function 281
  - bivariate 283
- probit-Poisson-log-normal model 184, 186, 187
- product purchase 27
- pseudo maximum likelihood 89, 218
- pseudo R-squared 119
- purchase frequency 260
- quantile regression 199
- quasi maximum likelihood 88
- re-transformation 66
- recreational trips 253
- recursive probabilities 40, 41, 45
- reduced form 161
  - linear 164
- relative partial effects 129
- renewal process 54
- Reset test 103
- robust Poisson regression 91, 92
- robust standard errors 95
- Roy model 167, 168
- sample segmentation 142
- sample selection 107
- score function 78
  - concave 85
  - convex 85
  - corrected 106
  - Poisson model 78
- seemingly unrelated Poisson regression 210
- selectivity
  - bias 170
  - bivariate normal 150
  - endogenous censoring 153
  - endogenous truncation 154
  - endogenous underreporting 197
  - hurdle model 178
  - indicator variable 148
  - negative binomial model 152



- non-normal errors 149
- selection equation 150
- semi-elasticity 66
- semi-parametric estimation 98
- semiparametric modeling
  - finite mixture 140
  - mixing distribution 139
  - multivariate models 217
  - panel models 229
  - quasi-likelihood 139
  - series expansions 138
- simultaneity 259
- single crossing 73, 182, 276
- single-index models 73
- size bias 91, 95
- size-biased Poisson 145
- spurious contagion 20
- Stirling's formula 22, 25
- stochastic process 11
  - contagion 18
    - birth process 14, 19, 33, 39
    - contagion 18, 20, 134
    - continuous time 10
    - count process 11
    - discrete time 10, 15
    - independence 11, 15
    - memory of 53
    - renewal process 17
    - state dependence 18
    - stationarity 11, 15, 18, 19
- stopped-sum distributions 36, 193
- strike data 2, 237
- survivor function 52, 53
- time series models 232
  - INAR process 235
  - negative binomial marginals 237
  - quasi likelihood estimation 234
  - semiparametric 233
  - unobserved heterogeneity 237
- Tobit model 146
- transformation to normality 216
- transition models 7, 50
- travel cost method 253
- treatment effect 72
- trivariate reduction 205
- truncation 30, 108, 143
  - at zero 143, 144
  - endogenous 154
  - hurdle 179
  - mean of normal 151
  - two-part process 30, 179
- two-crossings theorem 175
- two-part model 178, 186
- two-step procedure 155
- underdispersion 8, 45, 48, 59, 144, 180
  - Katz system 41
- underreporting 193
  - count amount model 109
  - endogenous 197
  - identification 195
  - information matrix 195
  - logistic 109
  - probit 198
  - random 109
  - threshold value 196
- unobserved heterogeneity 19, 60, 127, 148, 159
  - distribution 130
  - endogeneity 165
  - excess zeros 174
  - finite mixtures 139
  - in hurdle model 185
  - in Negbin model 152
  - parametric models for 130
  - semiparametric models for 130, 138
  - spell-specific 105
- urn model 18
- variance covariance matrix
  - Monte Carlo study 93
  - overestimation 91
  - robust 92
  - underestimation 91
- variance decomposition 129
- variance function 199
  - contagion 110
  - generalizations 111
  - linear 92, 134
  - misspecification tests 112
  - Negbin I 111
  - Negbin II 111
  - non-linearity parameter 111
  - overdispersion 110
  - Poisson model 102
  - quadratic 134
  - underdispersion 110

- unknown form 95
- unobserved heterogeneity 110
- Vuong test 122, 184
- non-nested models 122
- overlapping models 123
- pre-test 123
  
- waiting times 16, 50
- Wald test 113, 114
  - Poisson vs Negbin 114
- weakly exogenous regressors 230
- Weibull distribution 54
- Wishart distribution 249
  
- work absence days 97, 255
  
- zero-and-two inflation 259
- zero-deflation 190
- zero-inflation 110, 188
  - extensive margin 192
  - intensive margin 192
  - logit model 189
  - marginal mean effects 192
  - Poisson regression 188, 189
  - robust estimation 191
  - score test 117
  - strategic zeros 189