

Cambridge University Press

0521652340 - Introductory Statistics with Applications in General Insurance

I. B. Hossack, J. H. Pollard and B. Zehnwirth

Index

[More information](#)

## Author index

- Barcellos, A., 2, 3, 4, 6, 10, 12, 14, 18, 23, 260  
 Beard, R. E., 157, 160, 245, 247, 255, 256, 257, 258, 259, 260  
 Beyer, W. H., 86, 110, 260  
 Bhattacharya, G. K., 2, 26, 30, 31, 36, 57, 60, 77, 81, 96, 107, 108, 112, 119  
 Buchanan, R. A., 260  
 Devore, J. L., 26, 31, 32, 36, 42, 57, 60, 63, 81, 84, 87, 91, 96, 100, 101, 107, 108, 110, 112, 113, 116, 119, 156, 162, 260  
 Fisher, R. A., 177  
 Freund, J. E., 3, 4, 26, 30, 31, 32, 36, 42, 63, 64, 65, 66, 77, 81, 86, 87, 91, 96, 101, 107, 108, 110, 112, 119, 156, 162, 255, 260  
 Gillett, P., 6, 12, 23, 50, 96, 260  
 Gleeson, A. M., 260  
 Hart, D. G., 86, 101, 123, 128, 137, 145, 150, 156, 157, 175, 207, 208, 211, 223, 231, 234, 260  
 Hey, G. B., 36, 37, 156, 175, 260  
 Hille, E., 10, 12, 18, 23, 50, 260  
 Howe, B. A., 260  
 Hughes-Hallett, D., 6, 10, 12, 18, 26, 42, 50, 57, 77, 260  
 Johnson, N. L., 36, 37, 84, 101, 156, 175, 260  
 Johnson, R. A., 2, 26, 30, 31, 36, 57, 60, 77, 81, 96, 107, 108, 112, 119, 260  
 Kelton, W. D., 186, 188, 189, 190, 191, 260  
 Kotz, S., 84, 101, 260  
 Law, A. M., 186, 188, 189, 190, 191, 260  
 Mendenhall, W., 261  
 Ord, K., 26, 36, 77, 84, 91, 93, 96, 182, 186, 188, 190, 191, 261  
 Penttinen, T. 260  
 Pesonen, E., 260  
 Pitman, J., 26, 30, 31, 32, 36, 42, 60, 63, 64, 65, 66, 77, 81, 87, 91, 93, 96, 101, 109, 123, 156, 162, 188, 189, 190, 191, 255, 260  
 Pollard, J. H., 14, 42, 50, 57, 60, 63, 66, 77, 81, 84, 91, 93, 94, 96, 100, 101, 105, 107, 108, 109, 110, 112, 113, 115, 116, 119, 170, 182, 184, 186, 188, 189, 191, 260  
 Pooch, U. W., 182, 186, 188, 191, 260  
 Rand Corporation, 177  
 Ripley, B. D., 186, 188, 191, 260  
 Salas, S. L., 10, 12, 18, 23, 50, 260  
 Scheaffer, R. L. 261  
 Stein, S. K., 2, 3, 4, 6, 10, 12, 14, 18, 23, 260  
 Stuart, A., 26, 36, 77, 84, 91, 93, 96, 182, 186, 188, 190, 191, 261  
 Taylor, G. C., 207, 234, 261  
 Wackerly, D. D., 26, 31, 32, 36, 42, 57, 60, 63, 64, 65, 81, 87, 91, 96, 100, 101, 107, 108, 110, 112, 113, 116, 119, 156, 162, 184, 255, 261  
 Wall, J. A., 260  
 Yates, F., 177

Cambridge University Press

0521652340 - Introductory Statistics with Applications in General Insurance

I. B. Hossack, J. H. Pollard and B. Zehnwirth

Index

[More information](#)

## Subject index

- alpha particles, 88
- alternative hypothesis, 104
  - see also* hypothesis testing
- area under curve, 39, 41, 42–50, 54, 56, 127, 147, 148, 245, 251, 257
- average, *see* mean
- average payment per claim, 226, 238
- average weekly earnings (AWE), 217
- aviation insurance, 123
  
- bacteria, 88
- Bayes' methods, 151, 161–6
  - connection with credibility, 164
- Bayes' Theorem, 161–2, 175
- bimodal distribution, 152 n
- binomial distribution, 24 n. 68, 93–6
  - application, 183
  - maximum likelihood estimator, 120
  - mean, 93
  - normal approximation, 94, 183
  - parameters, 93
  - Poisson limit, 94–6
  - variance, 94
- blood counts, 88
- bonus-malus system, 167
- Box-Müller method, *see* random observations on the normal distribution
  
- casino, 26, 59–60
- catastrophe, 238
- census method, 122, 128, 139, 150
- central limit theorem, 68, 77–81, 87, 92, 94, 95, 97, 101, 105, 106, 111, 120, 158, 182, 187, 190, 191, 193, 244
- central moment, *see* moments, central
- central tendency, *see* location, measures
- chain-ladder method, 208–23
  - with inflation adjustment, 213–23, 231
- chance, games of, 25
  - see also* probability
- chi-square distribution, 112
- claim frequency distribution, 37, 38, 52, 53, 55, 90, 92, 98, 99, 102, 121
- claim frequency rate, 1, 110, 122, 123–8, 129, 139, 150, 245, 259
  - Bayesian estimation, 151, 162–6
  - distribution, 155–6
  - test of null hypothesis, 105, 114
- claim settlement
  - delays, 128, 129, 206–7, 223
  - pattern, 132, 137–45, 144, 146
- claim size distribution, 38, 39, 40, 41, 47, 48, 50, 51, 54, 56, 63, 76, 80, 81, 82, 86, 102, 120, 128–37, 145–7, 148, 249, 250, 259
  - second moment, 158
- claims
  - numbers, 29
  - amounts, 29
- coefficient of variation, 159
- coin tossing, 25, 26–8, 33, 103–4
  - see also* binomial distribution
- coin tossing experiment, 34, 35
- collateral data, 156, 157 n. 160
- combinatorial notation, 1, 3–4, 93 n
- community attitudes, 137
- computer estimation, 119
- conditional expectation, *see* expectation, conditional
- conditional mean, *see* mean, conditional
- conditional probability, *see* probability, conditional
- conditional variance, *see* variance, conditional
- confidence interval, 110–12, 125–6, 128, 150
  - tables and charts, 110
  - see also* interval estimation
- continuity correction, 79, 81, 92, 97
- court settlements, 137, 221
- credibility, 1, 151, 156–60
  - connected with Bayes' methods, 164
  - credibility factor, 151, 158
  - full credibility, 157–9
  - partial credibility, 160
- critical region, 104
  - see also* hypothesis testing

Cambridge University Press

0521652340 - Introductory Statistics with Applications in General Insurance

I. B. Hossack, J. H. Pollard and B. Zehnwirth

Index

[More information](#)*Subject index*

278

- cumulative distribution function, *see*  
distribution function
- De Moivre, 77, 243
- defects in materials, 88
- delay in claim reporting, 206–7  
*see also* delay table
- delay in claim settlement, *see under* claim  
settlement
- delay table, 237–8
- derivative, 1, 6–10, 42–50  
function of a function rule, 14 n  
higher, 9  
of exponential function, 15, 17  
of logarithmic function, 20, 23  
of polynomial, 8  
partial, 13, 14  
second, 9  
third, 9
- dice, 32, 50, 59
- differentiation, *see* derivative
- disjoint events, 25, 26–30
- dispersion, 68  
measure of, 52, 57–60
- distribution, 34, 35  
binomial, *see* binomial distribution  
continuous, 79, 88  
discrete, 79, 88  
exponential, 45, 47, 48  
gamma, *see* gamma distribution  
geometric, *see* geometric distribution  
importance of theoretical distributions,  
101  
log normal, *see* log normal distribution  
mode, 100  
negative binomial, *see* negative binomial  
distribution  
normal, *see* normal distribution  
Pareto, *see* Pareto distribution  
Poisson, *see* Poisson distribution  
positively skew, 66  
skew, 65–6  
uniform, 47  
*see also* distribution function and  
probability-density function
- distribution function, 34, 35, 39, 45, 46, 49, 56,  
63  
observed, 35, 41, 42, 49, 50  
*see also under* probability-density function
- dummy subscript, 2
- e (exponential number), 15, 16  
*see also* exponential function
- 'eighths' method, 122, 125, 128, 150
- estimate, 106, 107  
of claim frequency rate, 113  
*see also* point estimation
- estimation, 1  
by computer, 119  
by simulation, 182–4  
*see also* Bayes' methods, credibility, interval  
estimation, point estimation, simulation
- estimator, 107  
consistent, 107  
efficient, 108  
unbiased, 107  
*see also* point estimation
- event, 25  
disjoint, 25  
joint, 25  
mutually exclusive, 25
- excess, 122, 145–50
- excess of loss reinsurance, 1, 122, 137, 145–50  
treaty, 146, 148  
*see also* risk theory
- expectation, 52, 57, 61–3, 65, 255  
conditional, 63, 255  
properties, 61
- expenses, 122
- experience rating, 1, 151–76  
prospective, 151–2  
retrospective, 151
- experiment, 25, 35
- exponential distribution, 45, 47, 48, 147–8
- exponential function, 1, 5 n. 14–18  
derivative, 15, 17  
graph, 15
- exposure, 1, 122, 123–8, 139  
approximate methods, 123–8
- extrapolation  
warning, 84
- factorial notation, 1, 2–3, 86 n  
Stirling's approximation, 24 n
- flying bombs, 88
- free reserves, *see* risk theory
- functions of more than one variable, 12–14
- games of chance, 25, 35, 59–60, 78, 79, 93, 94,  
95, 103–4, 180–2
- gamma distribution, 68, 86–7, 152, 155, 190 n  
application, 98, 123  
in Bayesian estimation, 163–6  
mean, 87  
parameters, 86, 101, 153, 155  
probability-density function, 86, 87  
variance, 87  
versatility, 87
- gamma function, 86 n, 100
- geometric distribution, 97
- goodness of fit, 100  
test, 113 n, 145
- gross premium, 139
- group rating, 151, 166

Cambridge University Press

0521652340 - Introductory Statistics with Applications in General Insurance

I. B. Hossack, J. H. Pollard and B. Zehnwirth

Index

[More information](#)*Subject index*

279

- heterogeneity, 137
- heterogeneity of risk, 86, 96, 112–13, 151, 155, 167, 171  
in simulation, 205  
standard deviation measure, 155
- histogram, 39, 40, 82, 83, 94  
area, 39, 40
- homogeneous data, 154
- horse kicks, 88
- hypothesis testing, 103–7  
alternative hypothesis, 104  
critical region, 104  
examples, 105–7  
null hypothesis, 103, 106, 107  
significance level, 104
- IBNR, *see* incurred but not reported claims
- incurred but not reported claims, 126, 206, 207, 224, 233, 241  
delay table, 237–8  
estimation of provision, 237–9  
numbers of claims, 210–11
- independence, 25, 31–2, 57, 58, 59, 61, 75, 77, 89, 90, 93, 96, 106, 244  
in general insurance, 32
- individual data, 156, 157 n
- inference, 1, 101, 103–21, 161  
*see also* hypothesis testing, interval estimation, point estimation
- infinite series  
for  $e^x$ , 14, 16–18, 21  
for  $\ln(l + y)$ , 20–3
- inflation, 122, 129, 132, 133, 139, 140, 143, 148, 206, 207, 210, 213–23, 224, 225, 241, 242
- Institute of Actuaries of Australia, 216 n
- integration, 42–50, 54, 58
- intersection of events, 26–30
- interval estimation, 103, 108 n  
*see also* confidence interval
- joint events, 25, 26–30
- latitude, 12, 13
- least squares, *see* method of least squares
- levels of risk factor, 151
- liability claims  
delays in settlement, 206–7, 223, 238
- Liddy, D., 99, 121
- limit, 8, 26
- limited fluctuation, 160
- linear congruential generators, *see* random numbers
- loading  
for commission, 139  
for contingencies, 122, 129, 133  
for expenses, 122, 129, 133, 139  
for profit, 129, 133, 139  
for risk, *see* risk loading  
*see also* risk theory
- location, 107  
measures of, 52–7, 68  
*see also* mean, median, mode
- logarithm, 116  
change of base theorem, 19  
to base  $e$ , 18  
to base 10, 18  
*see also* logarithmic function
- logarithmic function, 1, 5 n, 18–23  
change of base theorem, 19  
derivative, 20, 23  
graph, 19  
relation to logarithm to base 10, 19
- log-linear models, 116  
*see also* multivariate methods
- log-normal distribution, 68, 76 n, 81–4, 102  
application, 123, 174, 198, 200  
application to excess of loss reinsurance, 147, 148–50  
comparison with Pareto distribution, 85–6  
confidence interval, 111–12  
mean, 81, 205  
parameters, 81, 101  
point estimates, 111, 120  
probability-density function, 81–2, 83  
simulation, 188–9, 204  
standard deviation, 205  
variance, 81
- longitude, 12, 13
- 'long-tail' classes of insurance, 128
- loss frequency, 148
- loss frequency rate, 253
- loss size distribution, 254
- Macquarie University, 242 n
- matrix theory, 170
- Matthews, T. J., 120
- maxima, 1, 10–14
- maximum likelihood estimation, 108–10, 112
- mean, 52–7, 120  
conditional, 52, 63–4, 86  
properties, 55  
unconditional, 63
- measures of dispersion, *see* coefficient of variation, standard deviation, variance
- median, 52, 53
- method of least squares, 115  
confidence interval, 119
- method of moments, 107
- minima, 1, 10–14
- minimization of function of several variables, 115, 117
- mode, 53, 100

Cambridge University Press

0521652340 - Introductory Statistics with Applications in General Insurance

I. B. Hossack, J. H. Pollard and B. Zehnwirth

Index

[More information](#)*Subject index*

280

- model, 101, 103, 104, 211–12
- moments, 52, 58, 61–3, 154  
 about the origin, 58, 62–3  
 central, 62–3  
 sample, 62  
 second, 158  
 third central moment, 63, 66
- multiplicative model, 116  
*see also* multivariate methods
- multivariate methods, 103, 112–20, 151  
 additive models, 114–16, 118  
 estimation of parameters, 114–19  
 log-linear models, 116  
 multiplicative models, 16
- mutations, 88
- mutually exclusive events, 91
- natural logarithm, *see* logarithmic function
- NCD, *see* no claim discount
- negative binomical distribution, 68, 96–101  
 application to heterogeneity of risk, 98–101  
 example of use, 120  
 fitting, 99  
 graph, 97  
 goodness of fit, 175  
 mean, 97  
 normal approximation, 97  
 parameters, 96, 101, 153, 154, 156  
 probability distribution, 96  
 simulation, 192–3  
 variance, 97  
 with parameters  $k = 6$ ,  $p = 0.6$ , 192
- no claim discount (NCD), 1, 126, 151, 152, 166–76  
 arguments for, 167  
 discrimination between good and bad risks, 171–2, 176  
 historical development, 167  
 simulation, 177, 198–205  
 step-back rules, 168, 171
- normal approximation  
 to binomial, 24 n, 94  
 to Poisson, 91–3  
*see also* central limit theorem
- normal distribution, 68–81, 102, 255–7, 259  
 distribution function, 69  
 independence, 75  
 mean, 68  
 parameters, 68, 101  
 probability-density function, 24 n, 68  
 simulation of, 186–8, 200, 204  
 standard deviation, 68  
 symmetry, 75  
 tables (ordinates and areas), 70–4  
*see also* central limit theorem
- null hypothesis, 103  
*see also* hypothesis testing
- outcome, 25
- outstanding claims provisions, 1, 206–42  
 average payment per claim, 226  
 chain-ladder method, 208–23, 241  
 chain-ladder method with inflation  
 adjustment, 213–23  
 development year, 208  
 direct future payments, 223–31  
 incurred but not reported claims, 233, 241  
 individual case estimates, 206, 208  
 inflation, 206, 207, 209, 213–23, 224, 225, 226, 227, 241  
 investment return (interest), 216, 218, 219, 220, 228, 241, 242  
 large claims, 234  
 mix of risks, 223  
 model compared with data, 211–212  
 other methods, 234  
 ratio method, 231–33  
 reinsurance, 234  
 separation method, 223–33, 241  
 tail, 234–7  
 total payments method, 231–3  
 trends in settlement, 206  
 year of origin, 208
- parameter, 106, 108, 110, 111  
 estimation, 156, 177
- parameters of a distribution, 68, 101
- Pareto distribution, 84–6  
 application, 123  
 comparison with log-normal, 85–6  
 distribution function, 84  
 estimation by method of moments, 120  
 mean, 84  
 parameters, 101  
 probability-density function, 84, 85, 86  
 variance, 85
- partial derivative, 13, 14, 115, 117
- Pascal triangle, 4
- pocket calculator, 5, 6, 14, 16, 19, 23
- point estimate, 125, 128
- point estimation, 103, 107–8  
 binomial distribution, 120  
 maximum likelihood, 108–10  
 method of moments, 108  
 negative binomial distribution, 120  
 Pareto distribution, 120  
 Poisson distribution, 109, 120
- Poisson distribution, 68, 88–93  
 application, 98, 102, 122, 157, 169, 198–200, 204  
 application to NCD, 169  
 application to risk theory, 245, 248  
 confidence interval, 110–11  
 examples of use, 105, 106, 109–10, 117, 120  
 fitting, 98–9

Cambridge University Press

0521652340 - Introductory Statistics with Applications in General Insurance

I. B. Hossack, J. H. Pollard and B. Zehnwirth

Index

[More information](#)*Subject index*

281

- graph, 88
- in Bayesian estimation, 163–6
- maximum likelihood estimator, 109
- mean, 88
- normal approximation, 91, 125, 245
- parameter, 88, 101
- prior distribution of parameter, 163–6
- probability distribution, 88
- relation to gamma distribution, 190 n
- simulation, 189–91, 204
- sum of Poisson variables, 89
- traditional examples, 88
- variance, 88
- with mean 0.1, 200
- with mean 0.5, 194
- with mean 1.0, 190
- power notation, 1, 5–6
- prior distribution, *see* Bayes' methods
- probability, 25
  - conditional, 25, 30–2, 63, 64, 161, 175
  - estimate, 25–6
  - games of chance, 25
- probability-density function, 34, 39, 40, 41, 42, 45, 47, 48, 54, 57, 65, 66
  - relation to distribution function, 44
- pseudo-random numbers. *see* random numbers
- random experiment, *see* experiment
- random fluctuations, *see* risk theory
- random fraction, 51
  - see also* random numbers, uniform distribution
- random numbers, 177–82
  - computer generation, 184–6
  - linear congruential generators, 184–6
  - mid-square method, 184
  - pseudo-random numbers, 184
  - random fractions, 180, 186, 189, 190, 194
  - tables, 177, 178–9
- random observations on the log-normal distributions, 188–9, 204
- random observations on the negative binomial distribution, 192–3
  - central limit theorem method, 193
  - using negative binomial tables, 192–3
- random observations on the normal distribution, 186–8, 204
  - Box-Müller method, 187, 200
  - central limit theorem method, 187, 188
  - using tables, 186, 188
- random observations on the Poisson distribution, 189–91
  - central limit theorem method, 191
  - normal approximation method, 191
  - product method, 190
  - using Poisson table, 189–90
- random variable, 25, 61, 63, 65
  - continuous, 34, 38–50
  - discrete, 34–8
  - simulation of, 177
  - sum of independent, 77
- reinsurance, 1, 60, 78, 84, 101, 107, 122, 137, 145–50, 234
  - treaty, 146
  - see also under* risk theory
- relative frequency distribution, 35, 36, 38
- retention, 148, 149
  - see also under* reinsurance, risk theory
- risk factors, 112–13, 152
  - levels, 113
- risk loading, 242, 243, 246
- risk premium, 1, 107, 122–50, 153, 160, 175, 243, 246, 248, 252, 253, 258
- risk theory, 243–59
  - application of Poisson distribution, 245, 248
  - assumption of normality, 255–7, 259
  - constant claim size, 245–7
  - excess of loss, 249, 251, 252
  - measure of risk, 244, 247
  - random fluctuations, 243, 252
  - reinsurance, 249, 251, 252, 254, 259
  - reserves (free), 243, 246, 248, 249, 252, 259
  - retention, 243, 249, 251, 257, 258, 259
  - riskless contract, 243–4
  - risk (safety) loading, 243, 246, 247, 248, 249, 253, 258, 259
  - rules of thumb, 258, 258–9
  - simulation, 259
  - skewness, 249
  - stochastic variation, 243
  - variable claim size, 248–55
- ruin, 243
- run-off, 206–7, 225, 233
  - tail, 234–7
  - trapezium, 220, 229
  - triangle, 207–8, 224
- sample size, 145
- sampling, 177
- scientific method, 104
- second moment about the origin, 248
- 'short-tail' classes of insurance, 128
- significance level, 104
  - see also* hypothesis testing
- simulation, 1, 168, 169, 177–205, 259
  - game of chance example, 180–2
  - general insurance examples, 193–5, 198–205
  - limitations of model, 203–4
  - number of simulations, 182–4, 204
- sensitivity analysis, 203–4
  - when to simulate, 195–6, *see also* random numbers

Cambridge University Press

0521652340 - Introductory Statistics with Applications in General Insurance

I. B. Hossack, J. H. Pollard and B. Zehnwirth

Index

[More information](#)*Subject index*

282

- skewness, 52, 65–6, 67, 77, 78, 81, 82, 84, 87, 249  
 measure, 6  
 positive, 65  
 slope of curve, 6–8, 44  
*see also* differentiation  
 standard deviation, 58, 64, 65  
 as measure of risk, 244  
 sample, 58, 59, 66  
 standardisation, 68, 69, 92, 94  
 stationary point, 11, 12, 13  
 statistical distribution, 52  
*see also* distribution  
 Stirling's approximation to  $(x - 1)!$ , 24 n  
 stochastic variation, *see under* risk theory  
 sub-committee, 3, 23  
 summation notation, 1, 2  
 symmetry, 79, 87  
 symmetric distribution, 65  
*see also* skewness
- tail of distribution, 78, 84, 101, 123  
*t*-distribution, 112  
 theory of risk, *see* risk theory  
 time horizon, 167, 174, 198
- transformation of random variable, 49, 51  
 transition matrix, 169, 175  
 trial, 25  
 'twenty-fourths' method, 126, 128
- unbiased coin, 103  
 uncertainty  
 measure of, 163, 166  
 underwriting loss, 131  
 uniform distribution, 47  
 unimodal distribution, 152  
 union of events, 26–30  
 unit normal distribution, 69, 87, 97, 126, 158,  
 160, 246, 249  
 urn model, 161, 162
- variance, 52, 57–60, 62, 120  
 conditional, 52, 64–5  
 properties, 58  
 sample, 58, 59  
 unconditional, 64, 65
- weighted least squares, 115  
*see also* method of least squares