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References

- Aitchison, J., and S. Silvey (1957): "The Generalization of Probit Analysis to the Case of Multiple Responses," *Biometrika*, 44, pp. 131–140.
- Amemiya, T. (1985): *Advanced Econometrics*, Harvard University Press.
- Amemiya, T. (1994): *Introduction to Statistics and Econometrics*, Harvard University Press.
- Baltagi, B.H. (2005): *Econometric Analysis of Panel Data* 3rd ed. Wiley.
- Bantle, C., and J.P. Haisken-DeNew (2002): "Smoke Signals: The Intergenerational Transmission of Smoking Behavior," *DIW Discussion Papers No. 277*.
- Barmby, T., M. Nolan, and R. Winkelmann (2001): "Contracted Workdays and Absence," *Manchester School*, 69, pp. 269–275.
- Beck, A.J., and B.E. Shipley (1989): "Recidivism of Prisoners Released in 1983," Special report, Bureau of Justice Statistics.
- Ben-Akiva, M., and S.R. Lerman (1985): *Discrete Choice Analysis: Theory and Application to Travel Demand*, MIT Press, Cambridge, MA.
- Berger, M.C. (1988): "Predicted Future Earnings and Choice of College Major," *Industrial and Labor Relations Review*, 41, pp. 418–429.
- Berkson, J. (1944): "Application of the Logistic Function to Bio-Assay," *Journal of the American Statistical Association*, 39, pp. 357–365.
- Berndt, E.K., B.H. Hall, R.E. Hall, and J.A. Hausman (1974): "Estimation and Inference in Nonlinear Structural Models," *Annals of Economic and Social Measurement* 3/4, 653–665.
- Berndt, E.R. (1990): *The Practice of Econometrics*, Addison-Wesley.
- Bertrand, B., and S. Mullainathan (2004): "Are Emily and Brendan More Employable than Latoya and Tyrone? Evidence on Racial Discrimination in the Labor Market from a Large Randomized Experiment," *American Economic Review*, 94, pp. 991–1013.
- Block, H., and J. Marschak (1960): "Random Orderings and Stochastic Theories of Response," in: I. Olkin (ed.), *Contributions To Probability And Statistics*, Stanford University Press, Stanford.

- Bolduc, D. (1999): "A Practical Technique to Estimate Multinomial Probit Models in Transportation," *Transportation Research Part B*, 33, pp. 63–79.
- Borjas, G.J. (1987): "Self-Selection and the Earnings of Immigrants," *American Economic Review* 77(4), pp. 531–53.
- Borjas, G.J. (1999): "Immigration and Welfare Magnets," *Journal of Labor Economics*, 17, pp. 607–637.
- Burtless, G. (1995): "The Case for Randomized Field Trials in Economic and Policy Research," *Journal of Economic Perspectives*, 9, pp. 63–84.
- Cameron, A.C., and P.K. Trivedi (1998): *Regression Analysis of Count Data*, Cambridge University Press, New York.
- Cappellari, L., and S.P. Jenkins (2003): "Multivariate Probit Regression Using Simulated Maximum Likelihood," *Stata Journal*, 3, pp. 278–294.
- Checkovich, T., and S. Stern (2002): "Shared caregiving responsibilities of adult siblings with elderly parents", *Journal of Human Resources*, 37, pp. 441–478.
- Collett, D. (2003): *Modelling Survival Data in Medical Research*, 2nd ed., Chapman & Hall, London.
- Costa, D.L. (1995): "Pensions and Retirement: Evidence from Union Army Veterans," *Quarterly Journal of Economics*, 110, pp. 297–319.
- Cox, D.R. (1972): "Regression Models and Life-Tables (with discussion)," *Journal of the Royal Statistical Society, Series B*, 34, pp. 187–220.
- Cox, D.R. (1975): "Partial Likelihood," *Biometrika*, 62, pp. 269–276.
- Cox, D.R., and D. Oakes (1984): *Analysis of Survival Data*, Chapman & Hall, London.
- Cragg, J.G. (1971): "Some statistical models for limited dependent variables with application to the demand for durable goods," *Econometrica*, 39, pp. 829–844.
- Cramer, J.S. (1986): *Econometric Applications of Maximum Likelihood Methods*, Cambridge University Press.
- Cutler D., and E. Richardson (1997): "Measuring the Health of the U. S. Population", *Brookings Papers on Economic Activity, Microeconomics*, pp. 217–271.
- Cutler D., and E. Richardson (1998): "The Value of Health: 1970–1990," *American Economic Review*, 88, pp. 97–100.
- Davidson, R., and J.G. MacKinnon (1993): *Estimation and Inference in Econometrics*, Oxford University Press.
- DeGroot, M.H. (1986): *Probability and Statistics*, 2nd ed. , Addison-Wesley.
- Duan, N., W.G. Manning, C.N. Morris, and J.P. Newhouse (1983): "A comparison of alternative estimators for the demand for medical care," *Journal of Business and Economics Statistics* 1, pp. 115–126.
- Ederington, L.H. (1985): "Classification Models and Bond Ratings," *Financial Review*, 20, pp. 237–262.
- Ermisch, J.F., and N. Ogawa (1994): "Age at Motherhood in Japan," *Journal of Population Economics*, 7, pp. 393–420.

- Evans, W., and R. Schwab (1995): "Finishing High School and Starting College: Do Catholic Schools Make a Difference?," *Quarterly Journal of Economics*, 110, pp. 941–974.
- Fehr, E., and L. Goette (2004): "Do Workers Work More When Wages Are High?" *IZA Discussion Paper No. 1002*.
- Fienberg, S.E. (1980): *The Analysis of Cross-Classified Categorical Data*. MIT Press, Cambridge, MA.
- Finney, D.J. (1971): *Probit Analysis*, 3rd ed., Cambridge University Press.
- Frey, B.S., and A. Stutzer (2002): *Happiness and Economics: How the Economy and Institutions Affect Human Well-Being*, Princeton University Press.
- Genesove D., and C.J. Mayer (1997): "Equity and Time to Sale in the Real Estate Market," *American Economic Review*, 87, pp. 255–269.
- Genz, A. (1992): "Numerical Computation of Multivariate Normal Probabilities," *Journal of Computational and Graphical Statistics*, 1, pp. 141–149.
- Gouriéroux, C., A. Monfort, and A. Trognon (1984): Pseudo-Maximum Likelihood Methods: Theory, *Econometrica*, 52, pp. 681–700.
- Gouriéroux, C., and A. Monfort (1996): *Simulation-based Econometric Methods*, Oxford University Press, Oxford.
- Greene, W.H. (2003): *Econometric Analysis*, 5th ed., Prentice-Hall.
- Gronau, R. (1974): "Wage comparisons - a Selectivity Bias," *Journal of Political Economy* 82, pp. 1119–1143.
- Gurland, J., I. Lee, and P.A. Dahm (1960): "Polychotomous Quantal Response in Biological Assay," *Biometrics*, 16, pp. 382–398.
- Gustafsson, S.S. (2001): "Optimal Age at Motherhood. Theoretical and Empirical Considerations on Postponement of Maternity in Europe," *Journal of Population Economics*, 14, pp. 225–247.
- Gustafsson, S.S., E. Kenjoh, and C.M.M.P. Wetzels (2002): "The role of Education in Postponement of Maternity in Britain, Germany, The Netherlands and Sweden," in: Ruspini, E., and A. Dale (eds.), *The Gender Dimension of Social Change: The Contribution of Dynamic Research to the Study of Women's Life Courses*, The Policy Press, Bristol, pp. 55–79.
- Hamilton, V., and B. Hamilton (1997): "Alcohol and earnings: Does drinking yield a wage premium?," *Canadian Journal of Economics*, 30, pp. 135–151.
- Hanemann, W.M. (1984): "Welfare Evaluations in Contingent Valuation experiments with Discrete Responses," *American Journal of Agricultural Economics*, 66, pp. 332–341.
- Hartog, J., and R. Winkelmann (2003): "Comparing migrants to non-migrants: The case of Dutch migration to New Zealand," *Journal of Population Economics*, 16, pp. 683–705.
- Hausman, J.A., B.H. Hall, and Z. Griliches (1984): "Econometric Models for Count Data with an Application to the Patents-R&D Relationship," *Econometrica*, 52, pp. 909–938.

- Hausman, J.A., and D.L. McFadden (1986): "A Specification Test for the Multinomial Logit Model," *Econometrica*, 52, pp. 1219–1240.
- Heckman, J.J. (1974): "Shadow Prices, Market Wages, and Labor Supply," *Econometrica*, 42, pp. 679–694.
- Heckman, J.J. (1979): "Sample Selection as a Specification Error," *Econometrica*, 47, pp. 153–161.
- Heckman, J.J., J.L. Tobias, and E. Vytlacil (2003): "Simple Estimators for Treatment Parameters in a Latent Variable Framework," *Review of Economics and Statistics*, 85, pp. 748–755.
- Heckman, J.J., R.J. Lalonde, and J.A. Smith (1999): "The Economics and Econometrics of Active Labor Market Programs," in: O.C. Ashenfelter, and D. Card (eds.) *Handbook of Labor Economics*, Volume 3A, Elsevier North-Holland, Chapter 31.
- Heckman, J.J., and B. Honoré (1990): "The empirical content of the Roy model," *Econometrica*, 58, pp. 1121–1149.
- Heckman, J.J., and E. Vytlacil (2005): "Structural Equations, Treatment Effects, and Econometric Policy Evaluation," *Econometrica*, 73, pp. 669–738.
- Heckman, J.J., and J.A. Smith (1995): "Social Experiments Assessing the Case for Social Experiments," *Journal of Economic Perspectives*, 9, pp. 85–110.
- Heckman, J.J., and R. Robb (1985): "Alternative Methods for Estimating The Impact of Interventions," in: J. Heckman, and B. Singer (eds.), *Longitudinal Analysis of Labor Market Data*, Cambridge (USA).
- Hoffmann, S.D., and G.J. Duncan (1988): "Multinomial and Conditional Logit Discrete-Choice Models in Demography," *Demography*, 25, pp. 415–427.
- Hogg, R.V., and A.T. Craig (1989): *Introduction to Mathematical Statistics*, 4th ed., Macmillan.
- Holland, P.W. (1986): "Statistics and Causal Inference," *Journal of the American Statistical Association*, 81, pp. 945–960.
- Horowitz, J.L. (1998): *Semiparametric Methods in Econometrics*, Lecture Notes in Statistics Vol.131, Springer.
- Hsiao, C. (2003): *Analysis of Panel Data*, Econometric Society Monographs No.34, Cambridge University Press.
- Jenkins, S.P. (1995): "Easy Ways to Estimate Discrete Time Duration Models," *Oxford Bulletin of Economics and Statistics*, 57, pp. 129–138.
- Kaiser, U., and A. Spitz (2002): "Quantification of Qualitative Data Using Ordered Probit Models," in: G. Poser, and D. Bloesch (eds.), *Economic Survey and Data Analysis, CIRET Conference Proceedings Paris*, pp. 325–343.
- Kalbfleisch, J.D., and R.L. Prentice (2002): *The Statistical Analysis of Failure Time Data*, 2nd ed., Wiley, New York.
- Kennan, J. (1985): "The Duration of Contract Strikes in U.S. Manufacturing," *Journal of Econometrics*, 28, pp. 5–28.

- Kiefer, N.M. (1988): "Economic Duration Data and Hazard Functions," *Journal of Economic Literature*, 26, pp. 646–679.
- Killingsworth, M. (1983): *Labor Supply*, Cambridge University Press.
- Klein, J.P., and M.L. Moeschberger (2003): *Survival Analysis: Techniques for Censored and Truncated Data*, 2nd ed., Springer, New York.
- Kockelman, K.M., and Y.-J. Kweon (2002): "Driver injury severity: an application of ordered probit models," *Accident Analysis & Prevention*, 34, pp. 313–321.
- Läärä, E., and J.N. Matthews (1985): "The Equivalence of two models for ordinal data," *Biometrika*, 72, pp. 206–207.
- Lancaster, T. (1979): "Econometric Methods for the Duration of Unemployment," *Econometrica*, 47, pp. 939–956.
- Lancaster, T. (1990): *The Econometric Analysis of Transition Data*, Cambridge University Press.
- Layard, R. (2005): *Happiness: Lessons from a New Science*, Penguin Press.
- Lee, L.-F. (1978): "Unionism and wage rates: a simultaneous equations model with qualitative and limited dependent variables," *International Economic Review*, 19, pp. 415–433.
- Luce, R. D. (1959): *Individual Choice Behavior*, Wiley, New York.
- Luce, R. D., and P. Supes (1965): "Preference, Utility, and Subjective Probability," in: R. Luce, R. Bush, and E. Galanter (eds.), *Handbook Of Mathematical Psychology*, Wiley, New York.
- Maddala, G.S. (1983): *Limited Dependent and Qualitative Variables in Econometrics*, Cambridge University Press.
- Manski, C.F. (1995): *Identification Problems in the Social Sciences*, Harvard University Press.
- Marschak, J. (1960): "Binary Choice Constraints on Random Utility Indicators," in: K. Arrow (ed.), *Stanford Symposium On Mathematical Methods In The Social Sciences*, Stanford University Press, Stanford.
- McCloskey, D.N. (1985): "The Loss Function Has Been Mislaid: The Rhetoric of Significance Tests," *American Economic Review*, 75, 201–205.
- McCullagh, P. (1980): "Regression Models for Ordinal Data," *Journal of the Royal Statistical Society. Series B (Methodological)*, 42, pp. 109–142.
- McFadden, D.L. (1968): "The Revealed Preferences of a Public Bureaucracy," Department of Economics, University of California, Berkeley.
- McFadden, D.L. (1974a): "Conditional Logit Analysis of Qualitative Choice Behavior," in: P. Zarembka (ed.), *Frontiers In Econometrics*, Academic Press, New York, pp. 105–142.
- McFadden, D.L. (1974b): "The Measurement of Urban Travel Demand," *Journal of Public Economics*, 3, pp. 303–328.
- McFadden, D.L. (1981): "Econometric Models of Probabilistic Choice," in: C.F. Manski, and D. McFadden (eds.), *Structural Analysis of Discrete Data with Econometric Applications*, MIT Press.

- McFadden, D.L. (1984): "Econometric Analysis of Qualitative Response Models," in: Z. Griliches and M. Intriligator (eds.), *Handbook of Econometrics*, Vol. II, Elsevier, Amsterdam, pp. 1396–1456.
- McKelvey, R.D. and W. Zavoina (1975): "A statistical model for the analysis of ordinal level dependent variables," *Journal of Mathematical Sociology*, 4, pp. 103–120.
- Moffitt, R. (1991): Program Evaluation with Nonexperimental Data, *Evaluation Review*, 15:291-314.
- Morgan, S.P. (1996): "Characteristic Features of Modern American Fertility," *Population and Development Review*, 22, Supplement: Fertility in the United States: New Patterns, New Theories, pp. 19-63.
- Mroz, T.A. (1987): "The Sensitivity of an Empirical Model of Married Women's Hours of Work to Economic and Statistical Assumptions," *Econometrica*, 55, pp. 765–799
- Olsen, R.J. (1978): "Note on the Uniqueness of the Maximum Likelihood Estimator for the Tobit Model," *Econometrica*, 46, pp. 1211–1215.
- Paap, R., and P.H. Franses (2000): "A Dynamic Multinomial Probit Model for Brand Choice with Different Long-Run Effects of Marketing-Mix Variables," *Journal of Applied Econometrics*, 15, pp. 717–744.
- Pagan, A., and A. Ullah (1999): *Nonparametric Econometrics*, Cambridge University Press.
- Pohlmeier, W., and V. Ulrich (1995): "An Econometric Model of the Two-Part Decision Making Process in the Demand for Health Care," *Journal of Human Resources*, 30, pp. 339–361.
- Powell, J.L. (1984): "Least squares absolute deviations estimation for the censored regression model," *Journal of Econometrics*, 25, pp. 303–325.
- Rao, C.R. (1948) Large sample tests of hypotheses involving several parameters with applications to problems of estimation, *Proceedings of the Cambridge Philosophical Society* 44, 50-57.
- Rose, N.L. (1990): "Profitability and Product Quality: Economic Determinants of Airline Safety Performance," *The Journal of Political Economy*, 98, pp. 944–964.
- Rothenberg, T.J. (1971): Identification in parametric models, *Econometrica*, 39, 577-591.
- Roy, A.D. (1951): "Some Thoughts on the Distribution of Earnings," *Oxford Economic Papers*, 3, pp. 135–146.
- Rubin, D.B. (1974): "Estimating Causal Effects of Treatments in Randomized and Nonrandomized Studies," *Journal of Educational Psychology*, 66, pp. 688–701.
- Sander, W. (1992): "The Effect of Women's Schooling on Fertility," *Economics Letters*, 40, pp. 229-233.
- Schmidt, P., and R.P. Strauss (1975): "The Prediction of Occupation Using Multiple Logit Models," *International Economic Review*, 16, pp. 471–486.

- Schultz, T.P. (2004): "School Subsidies for the Poor: Evaluating the Mexican Progresa Poverty Program," *Journal of Development Economics*, 74, pp. 199–250.
- Smith, R., and R. Blundell (1986): "An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply," *Econometrica*, 54, pp. 679–686.
- Solon, G. (1999): "Intergenerational Mobility in the Labor Market," in: O.C. Ashenfelter, and D. Card (eds.) *Handbook of Labor Economics*, Volume 3A, Elsevier North-Holland, pp. 1761–1800.
- Spencer, D.E. (1985): "Money demand and the price level," *Review of Economics and Statistics*, 67(3), 490–496.
- Stafford, S.L. (2000): "The Impact of Environmental Regulations on the Location of Firms in the Hazardous Waste Management Industry," *Land Economics*, 76, pp. 569–589.
- Terza, J.V. (1985): "Ordinal Probit: A Generalization," *Communications in Statistics – Theory and Methods*, 14, pp. 1–11.
- Terza, J.V. (1998): "Estimating Count Data Models with Endogenous Switching: Sample Selection and Endogenous Treatment Effects," *Journal of Econometrics*, 84, pp. 129–154.
- Terza, J.V. (2002): "Alcohol Abuse and Employment: A Second Look," *Journal of Applied Econometrics*, 17, pp. 393–404.
- Theil, H. (1969): "A Multinomial Extension of the Linear Logit Model," *International Economic Review*, 10, pp. 251–259.
- Theil, H. (1970): "On the Estimation of Relationships Involving Qualitative Variables," *American Journal of Sociology*, 76, pp. 103–154.
- Thurstone, L. (1927): "A Law of Comparative Judgment," *Psychological Review*, 34, pp. 273–286.
- Tobin, J. (1958): "Estimation of Relationships for Limited Dependent Variables," *Econometrica*, 26, pp. 24–36.
- Train, K.E. (2003): *Discrete Choice Methods with Simulation*, New York, Cambridge University Press.
- Tutz, G. (1991): "Sequential Models in Categorical Regression," *Computational Statistics and Data Analysis*, 11, pp. 275–295.
- Van den Berg (2001): "Duration Models: Specification, Identification, and Multiple Durations," in: J.J. Heckman, and E. Leamer (eds.) *Handbook of Econometrics*, Volume V, North-Holland, Amsterdam.
- Wald, A. (1943) Tests for statistical hypotheses concerning several parameters when the number of observations is large, *Transactions of the American Mathematical Society* 54, 426–482.
- White, H. (1982): Maximum Likelihood Estimation of Misspecified Models, *Econometrica*, 50, 1–25.
- Willis, R.J. (1973): "A New Approach to the Economic Theory of Fertility Behavior," *Journal of Political Economy*, 81, pp. S14–S64. Reprinted in: T.W. Schultz (ed.) (1974): *Economics of the Family: Marriage, Children and Human Capital*, University of Chicago Press, Chicago and London.

- Willis, R.J., and S. Rosen (1979): "Education and Self-Selection," *Journal of Political Economy*, 87, pp. S7–36.
- Winkelmann, R. (1998): "Count Data Models with Selectivity," *Econometric Reviews*, 17, pp. 339–359.
- Winkelmann, R. (2003): *Econometric Analysis of Count Data*, 4th ed., Springer Verlag, Berlin.
- Winkelmann, R. (2004): "Health Care Reform and the Number of Doctor Visits - An Econometric Analysis," *Journal of Applied Econometrics*, 19, pp. 455–472.
- Winkelmann, R., and K.F. Zimmermann (1994): "Count Data Models for Demographic Data," *Mathematical Population Studies*, 4, pp. 205–221.
- Winship, C., and R.D. Mare (1984): "Regression Models with Ordinal Variables," *American Sociological Review*, 49, pp. 512–525.
- Wooldridge, J.M. (2002): *Econometric Analysis of Cross Section and Panel Data*, MIT Press.
- Yatchew, A., and Z. Griliches (1985): "Specification error in probit models," *Review of Economics and Statistics*, 67, pp. 134–139.

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