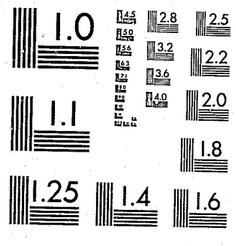

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PROMISING STATISTICAL METHODS FOR ESTIMATING MODELS OF POST-RELEASE CRIMINAL ACTIVITY

by

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Which type of statistical method is most appropriate for estimating a model of post-release criminal activity depends on the nature of the dependent and independent variables included in the model. The fact that our models are causal models means that certain types of methods which make no assumptions concerning causality are not as appropriate as they would be in a more exploratory analysis. However, we consider both causal and non-causal modeling techniques although the causal nature of our analysis biases us against non-causal techniques.

Most authors believe that no single measure of post-release criminal activity is appropriate, but rather that a number of measures which reflect the timing, frequency and seriousness of criminal activity should be utilized when evaluating correctional programs (for example see Sechrest, White, and Brown, 1979). For a discussion of various measures of recidivism see Waldo and Griswold (1979). We will discuss appropriate statistical models for one commonly used type of measure for each dimension of recidivism.

1. Timing

The most commonly used measure of timing is the length of time until an offense occurs. This variable requires considerable care in statistical analysis as it is nonnegative, skewed and truncated from above. The nonnegativity arises from the fact that it is not possible to observe negative times until recidivism. The distribution of this variable is generally quite skewed as those who return to crime generally do so quite quickly, although lower rates of failure occur throguhout the follow-up period. The truncation of the variable arises because we cannot observe a value of the dependent variable greater than the length of time for which an individual's activites are followed.

A number of authors have suggested alternative methods of analyzing this variable. Stollmack and Harris (1974) suggest that the failure rate (recidivism rate) follows a negative exponential distribution. This method assumes that the failure rate is a constant independent of either the length of time since program participation or the characteristics of the individuals involved. In addition, the Stollmack-Harris method assumes that all individuals eventually recidivate. Recently a number of authors have developed methods which relax the various assumptions of the Stollmack-Harris method. Maltz and McCleary (1977) develop a negative exponential failure method that allows the ultimate failure rate to approach some upper bound other than zero (i.e., they allow for the fact that some individuals will never recidivate). Bloom (1978) allows the failure rate to vary with length of time since program participation. Witte and Schmidt (1977) allow failure rates to vary and allow the rate of failure to depend on the personal characteristics and previous experience of the individuals being analyzed. Witte and Schmidt consider a number of alternative distributions (ordinary least squares, truncated normal, truncated exponential and truncated lognormal) in modeling the length of time until recidivism and find that both in terms of the maximized value of the likelihood function and within sample prediction that the truncated lognormal distribution is superior to any alternative distribution considered. However, they note that "the signs of all coefficients are the same by all techniques, and their levels of significance are roughly comparable" (Witte and Schmidt, 1977, p.308).

Table 1 contains the criteria upon which we evaluate the alternative methods which have been suggested for modeling the timing and other measures

TABLE 1

Criteria for Assessing Alternative Statistical Methods
for Estimating Recidivism Models

APPROPRIATENESS: How appropriate is the method for estimating the theoretical model?

High	- The method is well suited to estimating models of criminal justice outcome.
Moderate	- The method is suitable for modeling simple measures of criminal justice outcome (e.g., conviction/no conviction), but not more complex measures (measures of the seriousness or frequency of offense).
Low	- The method does not seem appropriate.

METHODOLOGICAL STRENGTH: How likely are the assumptions underlying the method to be met in typical evaluative situations?

Strong	- Assumptions will usually be met.
Moderate	- Assumptions will sometimes be met.
Weak	- Assumptions will rarely be met.

FLEXIBILITY: How well can the method adjust for varying follow-up periods and data?

High	- Variations in both follow-up and data can be adjusted for.
Moderate	- Some variations in either follow-up period or data can be adjusted for.
Low	- Few variations in either follow-up period or data can be adjusted for.

SENSITIVITY: How sensitive are estimates obtained using the methods to misspecification or data errors?

High	- The method is highly sensitive to data errors or misspecification.
Moderate	- The method is only moderately sensitive to data errors or misspecification.
Low	- The method is quite robust in the presence of data error or misspecification.

TABLE 1
(continued)

CONFIDENCE: Does the method provide adequate measures of statistical significance particularly for parameters relating to correctional programs?

High	- The method provides adequate measures of statistical significance.
Moderate	- The method provides some measures of statistical significance.
Low	- The method provides few if any measures of statistical significance.

TRANSFERABILITY: How well can a model estimated using this method be transferred to alternative geographic and program situations without reestimation?

High	- Estimated models can be easily transferred.
Moderate	- Estimated models can only be transferred under certain conditions.
Low	- Models must be reestimated.

COSTS: What are the professional and computer time requirements for model estimation and use? How likely are such requirements to be met?

High	- Professional skills and computer time requirements for both estimations and use would only be available from specialized consultants.
Moderate	- Professional skill and computer time requirements are high for estimation but generally available for use.
Low	- Professional skill and computer time for both estimation and use should be generally available.

UNDERSTANDABILITY: How well can the method and the empirical results emanating from it be understood by the practitioner and concerned public?

High	- The method and empirical results can be relatively easily explained to the non-specialist.
Moderate	- The non-specialist can at least intuitively understand the method and results.
Low	- The model would be difficult if not impossible to explain to the non-specialist.

of recidivism. Table 2 contains our evaluation, on these criteria, of alternative methods of estimating models of the timing of recidivism. As can be seen in Table 2, the truncated lognormal model scores most highly on appropriateness, methodological strength, flexibility and confidence. However, the simpler Stollmack-Harris, Maltz-McCleary and Witte-Schmidt OLS score more highly on understandability. The ultimate choice of a method thus must rest on the relative importance of understandability and more technical statistical concerns.

2 Frequency

The most commonly used measure of frequency for individuals is either an arrest or conviction rate (i.e., the number of arrests or convictions per unit of time free.)[1] As was the case with measures of the timing of recidivism, this variable requires some care in statistical analysis. The variable is nonnegative since we cannot observe negative numbers of arrests or convictions. In addition, the variable is skewed as low frequencies of arrest and conviction are more likely to be observed than high frequencies.

Few researchers have analyzed this variable in a multivariate setting; however, those who have have used either ordinary least squares analysis (for example, see Wolfgang, Figlio and Sellin, 1972) or Tobit analysis (for example, see Witte, 1980). Ordinary least squares analysis which assumes a continuous, symmetric normal distribution seems dubious technically although it is inexpensive to apply and relatively easy for the practitioner to understand. Tobit analysis assumes that there is some probability of a zero offense

TABLE 2

Assessment of Alternative Statistical Methods for Estimating Models of the Timing of Recidivism

Criterion \ Method	Stollmack -Harris	Maltz-McCleary	Bloom	Witte-Schmidt OLS	Witte-Schmidt Truncated Normal	Witte-Schmidt Truncated Exponential	Witte-Schmidt Truncated Lognormal
Appropriate-ness	Low	Moderate	Moderate to High	Low	Moderate to High	Moderate	High to Moderate
Methodologi-cal Strength	Low	Moderate	Moderate	Low	Moderate	Moderate	High to Moderate
Flexibility	Moderate	Moderate	Moderate	High	High	High	High
Sensitivity	Unknown	Unknown	Unknown	Moderate	Unknown	Unknown	Unknown
Confidence	Moderate	Moderate	Moderate	High	High	High	High
Transfer-ability	Moderate	Moderate to Low	Moderate to Low	Moderate to Low	Moderate to Low	Moderate to Low	Moderate to Low
Costs	Moderate to Low	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Understand-ability	Moderate to High	Moderate to High	Moderate	High	Moderate	Moderate	Moderate

rate (derived from a cumulation of part of the normal distribution) and that the probability of rates greater then zero follow the portion of the normal distribution not cumulated to form the zero probability. Thus, if approximately 30 percent of the individuals have no offenses during the period we would be fitting a distribution like that pictures in Figure 1 to the data.

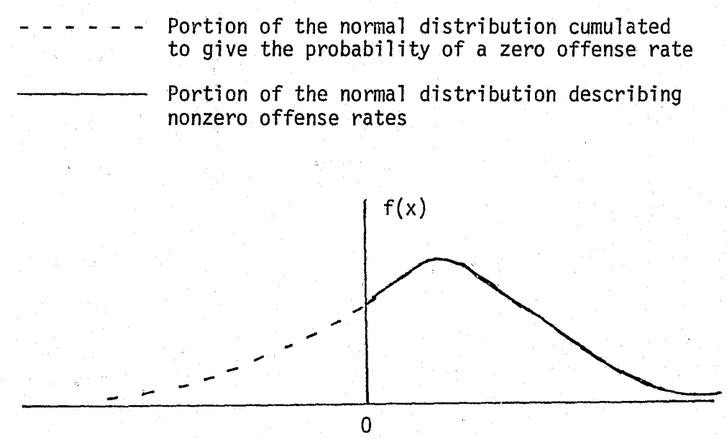

Figure 1: Tobit Model with a 30% Probability of Positive Offense Rate

If 60 percent committed offenses, only the negatively sloped portion of the normal curve would be used to fit positive offense rates. Tobit analysis seems more appropriate technically as it allows for the truncation and skewness of offense rate date; however, it is relatively costly to utilize since it uses maximum likelihood estimation techniques and is relatively difficult to explain to the lay person. Table 3 contains our ranking of ordinary least squares and Tobit analysis on the criteria outlined in Table 1.

TABLE 3

Assessment of Alternative Statistical Methods
for Estimating Offense Rate Models

Criterion \ Method	OLS	Tobit Analysis
Appropriateness	Low	High
Methodological Strength	Weak	Moderate
Flexibility	High	High
Sensitivity	Moderate	Unknown
Confidence	High	High
Transferability	High	Moderate
Costs	Low	Moderate
Understandability	High	Moderate

3. Seriousness

There is no generally agreed upon measure of the seriousness of criminal activity. A number of researchers have attempted to develop empirically based measures of seriousness. For a recent example, see Center for Studies in Criminology and Criminal Law (1978). Many of these measures of seriousness are continuous variables. As such, they suffer from the same truncation-at-zero problem and skewness discussed for offense rates in the previous section. The techniques considered there would seem to be appropriate methods of analysis. Wolfgang, Figlio and Sellin (1972) analyze the most popular of these seriousness scales (the Wolfgang-Sellin) using ordinary least squares.

Other researchers have attempted to develop measures of seriousness based on the degree of criminal justice system response. For example, Schmidt and Witte (1976) use the total time sentenced during a follow-up period as their measure of seriousness. They analyze this variable using Tobit analysis. Other researchers have classified criminal justice responses into a number of discrete categories. The simplest such discrete classification is the dichotomous classification offense/no offense. More complex categorical breaks have also been suggested (e.g., felony, misdemeanor, no offense; felony, misdemeanor, status offense, no offense; >1 offense, 1 offense, Ø offenses). Researchers have used a number of techniques to analyze these categorical measures of criminality. Many researchers have used ordinary least squares analysis (see Gottfredson and Beverly, 1962; and Wolfgang, Figlio and Sellin, 1972 for examples). Others have utilized various numerical taxonomic techniques such as predictive attribute analysis (see Wilkins and MacNaughton-Smith, 1964; and Service, 1972, for examples). Recently researchers have come to use increasingly sophisti-

cated statistical techniques: log-linear analysis (vanAlstyne and Gottfredson, 1978), discriminant analysis (Fair-Isaacs, Inc., 1971), probit analysis (Cook, 1975) and logit analysis (Witte and Schmidt, 1979). Fortunately, a number of authors have tried to evaluate the relative merits of these techniques. Simon (1971) compares a number of the earliest used techniques and also surveys previous comparisons. Her work indicates that ordinary least squares and predictive attribute analysis perform most satisfactorily. However, she does not consider the more sophisticated techniques used recently. Bishop (1969), Bishop, Fienberg and Holland (1975) and Fienberg (1977) suggest that log-linear analysis may be best when there is no causal theory, but that logit analysis may be more appropriate when there is. Press and Wilson (1978) have recently assessed the relative merits of logit and discriminant analysis while Theil(1971) discusses probit and logit analysis. Our assessment of alternative techniques for analyzing categorical data (see Table 4) must be considered preliminary as there is no currently available source, of which we are aware, that assesses all alternative statistical techniques. As can be seen in Table 4, no single method receives consistently high ratings. Logit analysis tends to score most highly on technical grounds while ordinary least squares, predictive attribute analysis and discriminant analysis score more highly in terms of costs and understandability.

4. Summary and Conclusions

In this paper we have surveyed statistical techniques which could and have been used to analyze commonly used measures of the timing, frequency and seriousness of post-release criminal activity. We find that a wide

TABLE 4

Assessment of Alternative Statistical Methods for Estimating Categorical Measures of Recidivism

Criterion \ Method	Ordinary Least Squares	Predictive Attribute Analysis	Log-linear Analysis	Discriminant Analysis	Probit Analysis	Logit Analysis
Appropriateness	Low	Moderate	Moderate	Moderate	High	High
Methodological Strength	Weak	Moderate	Moderate	Moderate	Moderate	High
Flexibility	High	Moderate	Moderate	Moderate	High	High
Sensitivity	Moderate	Unknown	Unknown	Unknown	Unknown	Unknown
Confidence	High	Weak	High	High	High	High
Transferability	Moderate	Moderate	Moderate	Moderate to Low	Moderate to Low	Moderate to Low
Costs	Low	Low	Moderate	Moderate	Moderate to High	Moderate to High
Understandability	High	High	Moderate to Low	Moderate	Moderate to Low	Moderate to Low

variety of statistical techniques have been used to analyze most measures. We assess alternative techniques on the appropriateness, methodological strength, flexibility, sensitivity, confidence, transferability, costs and understandability. We find that simpler techniques such as ordinary least squares analysis have lower costs and are easier to understand for the practitioner. However, we find the application of such simple techniques to be questionable on technical grounds. We suggest that the technique to be utilized will depend on the relative importance of technical, and cost and understandability factors. However, the researcher using the simpler techniques should be warned that estimates obtained may fail to have desirable properties (e.g., unbiasedness, efficiency). It is particularly likely that estimated standard errors will be biased and that tests of significance may be inappropriate.

FOOTNOTE

[1] Group frequency, i.e., estimates of group recidivism rates, can be obtained from the models discussed in the previous section. When the follow-up period is the same for all individuals one may analyze the number of offenses instead of offense rate. See Wolfgang, Figlio and Sellin (1972) for an example.

REFERENCES

Bishop, Y.M.M. "Full Contingency Tables, Logits, and Split Contingency Tables," Biometrics, vol. 25 (1969), 383-400.

Bishop, Y.M.M., S.E. Fienberg and P.W. Holland. Discrete Multivariate Analysis: Theory and Practice. Cambridge, Mass.: The MIT Press, 1975.

Bloom, H.S. "Evaluating Human Service and Criminal Justice Programs by Modeling the Probability and Timing of Recidivism," Discussion Paper D78-9, Department of City and Regional Planning, Harvard University, 1978.

Fienberg, S.E. The Analysis of Cross-Classified Categorical Data. Cambridge, Mass.: The MIT Press, 1977.

Center for Studies in Criminology and Criminal Law. "National Survey of Crime Severity: Final National Level Geometric Means and Ratio Scores by Offense Stimuli Item," Working Paper, University of Pennsylvania, 1978.

Fair-Isaacs, Inc., Development of a Scoring System to Predict Success on Work Release, Report Prepared for the District of Columbia Department of Correction, 1971.

Gottfredson, D.M. and R.F. Beverly. "Development and Operational Use of Prediction Methods in Correctional Work," Procedings of the American Statistical Association, 1962.

Maltz, M.D. and R. McCleary. "The Mathematics of Behavioral Change," Evaluation Quarterly, vol. 1 (1977), 421-438.

Press, S.J. and S. Wilson. "Choosing between Logistic Regression and Discriminant Analysis," Journal of the American Statistical Association, vol. 73 (December, 1978), 699-705.

Schmidt, P. and A.D. Witte. "Determinants of Criminal Recidivism," Report to the North Carolina Department of Correction on Contract #33-045-275-12, September, 1976.

Sechrest, L., S.O. White and E.D. Brown (eds.). The Rehabilitation of Criminal Offenders: Problems and Prospects. Washington, D.C.:National Academy of Sciences, 1979.

Service, P. The Recidivism of Persons Released from Facilities of the North Carolina Department of Correction during January-July, 1968. Raleigh, N.C.: North Carolina Department of Correction, 1972.

Simon, F.H. Prediction Methods in Criminology. London: Her Majesty's Stationery Office, 1971.

Stollmack, S. And C.M. Harris. "Failure Rate Analysis Applied to Recidivism Data," Operations Research, vol.22 (1974) 1192-1205.

Theil, H. Principles of Econometrics. New York: John Wiley, 1971.

vanAlstyne, D.J. and M.R. Gottfredson, "A Multidimensional Contingency Table Analysis of Parole Outcome," Journal of Research in Crime and Delinquency, vol. 15 (July, 1978) 172-193.

Waldo, G. and D. Griswold. "Issues in the Measurement of Recidivism" in L. Sechrest, S.O. White and E.D. Brown (eds.). The Rehabilitation of Criminal Offenders: Problems and Prospects. Washington, D.C.: National Academy of Sciences, 1979, 225-250.

Wilkins, L. and P. MacNaughton-Smith. "New Prediction and Classification Methods in Criminology," Journal of Research in Crime and Delinquency, vol. 1 (1964) 19-32.

Witte, A.D. "Estimating the Economic Model of Crime with Individual Data," Quarterly Journal of Economics, vol. 94 (February, 1980) forthcoming.

Witte, A.D. and P. Schmidt. "An Analysis of Recidivism, Using the Truncated Lognormal Distribution," Journal of the Royal Statistical Society, Series C (Applied Statistics), vol. 26 (1977) 302-311.

Witte, A.D. and P. Schmidt. "An Analysis of the Type of Criminal Activity Using the Logit Model," Journal of Research in Crime and Delinquency, vol.16 (January, 1979) 164-179.

Wolfgang, M.E., R.M. Figlio and T. Sellin. Delinquency in a Birth Cohort. Chicago, Ill.: University of Chicago Press, 1972.

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