Efficient Estimation for Recurrent Events under Informative Censoring Using Generalized Method of Moments

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ABSTRACT

In this work, we develop semiparametric transformation models with a shared frailty variable for recurrent event data, accommodating correlation between the event process and censoring. Unlike standard shared-frailty proportional rate models, our framework allows nonproportional rate functions across covariates. Motivated by the decomposition of the rate function into shape and size components (Wang and Huang, 2014), we first adopt an inverse-rate weighting approach and then propose a generalized method of moments framework that integrates information from both components to improve efficiency. We establish their large-sample properties, evaluate finite- sample performance through simulations, and demonstrate practical utility with a real dataset.

Keywords: Generalized method of moments; Informative censoring; Recurrent event process

A Doubly Robust Instrumental Variable Approach for Estimating Average Treatment Effects in Time-to-Event Data with Unmeasured Confounding

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ABSTRACT

We propose a novel doubly robust instrumental variable (IV) estimator for estimating average treatment effects (ATEs) in time-to-event outcomes subject to unmeasured confounding. While IV methods are increasingly applied in real-world data analyses, existing approaches for survival outcomes often rely on restrictive assumptions and lack desirable statistical properties. Our method is derived from the efficient influence function (EIF), ensuring double robustness and achieving asymptotic efficiency. The framework accommodates flexible machine learning estimators, making it well suited for complex electronic health record (EHR) data. Through extensive simulations, we demonstrate the method's robustness, asymptotic normality, and strong finite-sample performance. We apply the estimator to EHR data on ICU patients with vasopressor-dependent septic shock, using physician prescribing preference as the instrument to evaluate the effect of hydrocortisone on mortality. Results indicate no significant benefit or harm, providing reliable evidence for clinical decision-making. This doubly robust IV approach expands methodological tools for survival analysis under unmeasured confounding and enhances the validity of causal inference in real-world settings.

Keywords: Average treatment effect, efficient influence function, instrumental variable, time-to-event data, unmeasured confounding

A Quantile Cure Model with Partially Functional Covariate Effects

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ABSTRACT

The quantile regression has several attractive features, such as its ability to allow covariate effects to vary at different quantile levels and to handle heteroscedasticity in data easily, which make it a viable alternative when analyzing data with continuous outcomes in recent years. In particular, it has been used in modeling survival data with and without a cured fraction. In this work, we propose novel estimating equation approaches to estimate a mixture cure model where the latency survival time is modeled by a quantile regression. The proposed estimation methods enjoy a double robustness in the sense that a misspecification in one of the two parts in the mixture cure model will not affect the estimation in the other part. The methods do not require the global log-linear assumption in the quantile regression, and they allow mixed effects of functional and constant effects in the regression when the log-linear assumption is hold in an interval of quantile levels. We established the asymptotic properties of the proposed estimators. Our simulation studies demonstrated the double robustness and the efficiency gains in the proposed estimators. An application of the proposed model and methods to data from a lung cancer study revealed new and interesting findings that were not reported in a previous analysis of the data.

Keywords: Estimating equation; Inverse probability censoring weight; Mixture cure model; Quantile regression model

Semiparametric Analysis of Multivariate Panel Count Data with Informative Observation Processes

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ABSTRACT

Multivariate panel count data arise in studies involving several related types of recurrent events in which the study subjects are examined periodically over time. The observation times may vary from subject to subject and carry information about the underlying recurrent event processes of interest. In this paper, we propose a joint modeling approach to account for the informative observation processes using bivariate shared frailty models. Estimating equations and an EM algorithm are developed for the parameter estimation, and the resulting estimators are shown to be consistent and asymptotically normal. The proposed methods are evaluated through simulation studies and illustrated with an application to data from a skin cancer clinical trial.

Keywords: EM algorithm; Estimating equation; Informative observation times; Multivariate panel count data