Layer, Kevin; Johnson, Andrew L.; Sickles, Robin C.; Ferrier, Gary D.

Direction selection in stochastic directional distance functions. (English) [Zbl 1430.90410]


Summary: Researchers rely on the distance function to model multiple product production using multiple inputs. A stochastic directional distance function (SDDF) allows for noise in potentially all input and output variables. Yet, when estimated, the direction selected will affect the functional estimates because deviations from the estimated function are minimized in the specified direction. Specifically, the parameters of the parametric SDDF are point identified when the direction is specified; we show that the parameters of the parametric SDDF are set identified when multiple directions are considered. Further, the set of identified parameters can be narrowed via data-driven approaches to restrict the directions considered. We demonstrate a similar narrowing of the identified parameter set for a shape constrained nonparametric method, where the shape constraints impose standard features of a cost function such as monotonicity and convexity.

Our Monte Carlo simulation studies reveal significant improvements, as measured by out of sample radial mean squared error, in functional estimates when we use a directional distance function with an appropriately selected direction and the errors are uncorrelated across variables. We show that these benefits increase as the correlation in error terms across variables increase. This correlation is a type of endogeneity that is common in production settings. From our Monte Carlo simulations we conclude that selecting a direction that is approximately orthogonal to the estimated function in the central region of the data gives significantly better estimates relative to the directions commonly used in the literature. For practitioners, our results imply that selecting a direction vector that has non-zero components for all variables that may have measurement error provides a significant improvement in the estimator’s performance. We illustrate these results using cost and production data from samples of approximately 500 US hospitals per year operating in 2007, 2008, and 2009, respectively, and find that the shape constrained nonparametric methods provide a significant increase in flexibility over second order local approximation parametric methods.

MSC:

90C08 Special problems of linear programming (transportation, multi-index, data envelopment analysis, etc.)
62G08 Nonparametric regression and quantile regression
62P20 Applications of statistics to economics
90B50 Management decision making, including multiple objectives

Keywords:
nonparametric regression; shape constraints; data envelopment analysis; hospital production

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