Spatial Statistics and Econometrics for Models in Fisheries Economics: Discussion

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Introduction

The papers in this session provoked the author's interest in considering how one might apply spatial econometric and spatial statistical techniques to issues in fisheries economics. The author will not consider specific issues raised in the session papers, but instead will briefly introduce spatial modeling techniques that can be applied to two recurring themes in the session. The first theme is prediction of the spatial variation of revenue at a particular site location, addressed with the use of spatial prediction models, or kriging. The second theme is the well-established use of discrete choice models in the context of fisher's site choice decisions and the potential application of spatial discrete choice models. In both cases, the author takes a strictly empirical approach to the problem and points out where these methods may be applicable in the session's papers.

Spatial Prediction

Smith considers in detail the importance of revenue as a determinant of site choice. Curtis and Hicks also use revenue as a fundamental piece in the derivation of expected returns at a site. Revenue depends on the price paid for the harvest and the costs of catching the fish that are likely to be invariant to location choice once at a fishing site. Harvest, though, is dependent on the fishing conditions and the supply of fish at the site, and the supply is dependent on oceanographic conditions that affect the fish such as water temperature and food supply. These oceanographic conditions do not change suddenly, but are more likely to follow food source migration patterns and spatially continuous changes in ocean conditions. Therefore, site revenue is spatially correlated because the supply of fish in close locations is spatially correlated.

To formulate the process, the data are thought of as partial realizations of a spatial stochastic process, $\{Z(s): s \in D\}$ where D is a positive dimensional region and s is a continuous spatial index (Cressie). In other words, the process (the amount harvested, or the revenue if price and cost is known) is observed at specific locations (the fishing sites), but exists continuously throughout space.[1] The semivariogram and kriging can be used to forecast the harvest at unobserved site locations given observed harvests at nearby locations.[2] The semivariogram describes the pairwise variance between points such that with spatial correlation for pairs at short distances the variance is low but increasing as distance between point pairs increases. By using a nonlinear least squares optimization routine a theoretical semivariogram function can be fit to the pairwise variances of the sample points. This function represents the spatial correlation with parameters defining the distance over which the correlation is present. The kriging estimator uses any observed information about the site locations (e.g., ocean temperature, weather conditions, biomass) and the fitted semivariogram to predict values and estimator variance at unobserved locations (e.g., Cressie, Haining). The use of kriging to interpolate the mean and the variance of revenue at unknown locations offers another

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[1] Spatial and temporal data can be included in this spatial stochastic process by considering $Z(s, t)$.

[2] Curtis actually uses a spatial autoregressive model to forecast revenue, which is an alternative method. Because continuous spatial econometric models are increasingly familiar, a discussion of the less well-known spatial statistical technique was chosen for this discussion.

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alternative to the methods Smith describes, as well as potentially acting as a data augmentation technique for locations that were not chosen in a given period.

Discrete Spatial Econometrics

While kriging can be used to predict the mean and the variance of revenue at any location, discrete choice spatial econometric models may provide insight into the behavior underlying spatial location decisions. All three papers in the section employ discrete choice methods. Smith describes the random-utility model (RUM) as the starting point for fisheries discrete choice modeling. Curtis and Hicks extend this and realize the dependencies of fishing locations based on past location choices. In fact, their valuation function describing expected wealth as a function of distance weighted forecasts of wealth at contiguous site locations is an excellent incorporation of spatial information. Mistiaen and Strand focus their efforts less explicitly on dependent location choice decisions, but on the flexibility of the discrete choice specification in allowing heterogeneous risk preferences. The random parameter's logit model they employ is similar to a proposed method for estimating spatial discrete choice models, the Gibbs sampler.

Estimation of discrete models with spatially lagged dependent variables and spatial error dependence is an active area of research, particularly the spatial probit model. Methods have been proposed to estimate spatial probit models using the EM algorithm (McMillen), GMM estimation of the probit score vector (Pinkse and Slade), simulated recursive sampling (Beron and Vijverberg, Vijverberg), Bayesian methods using the Gibbs sampler (Bolduc, Fortin, and Gordon, LeSage 2000), and variations on generalized weighted regression techniques (LeSage 1999). To this author's knowledge, there are no proposed methods for multinomial spatial location models, but work on the simpler binary models may provide insights and clues into possible extensions to the multinomial case.

Conclusions

This discussion briefly introduces kriging and spatial discrete choice models that have potential application in spatial fisheries models of location choice. Kriging methods are useful in better predicting expectations and variances in revenue at different locations and the work in spatial discrete choice models should provide insight into extensions that can be applied in multiple location decision models. It is hoped that these techniques will allow the research presented in this session to be further extended and improved upon with more robust and explicit use of spatial information.

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