6. Appendix: The Spatial-Statistics, Spatial-Econometrics, and Network-Analysis Traditions (an extremely brief discussion of the differences in emphases)

Anselin (2006), Griffith & Paelinck (2007), and many others discern two approaches to spatial analysis: spatial statistics and spatial econometrics. "In practice, spatial econometrics and spatial statistics reflect traditions of their parent disciplines. In other words, they share much in common, with some notably differing emphases… Econometrics…is the 'setting up of mathematical models describing economic relationships…, testing the validity of such hypotheses and estimating the parameters in order to obtain a measure of the strengths of the influences of the different independent variables' (Bannock et al. 2003)… 'Statistics is the science of gaining information from numerical data' (Moore 1995, p. 2). It provides data-interrogative tools and conceptual frameworks for gaining understanding through empirical-based induction, and involves data acquisition, data analysis, and statistical inference" (Griffith & Paelinck 2007:210). Thus, the distinction rests, on the one hand, on the relative emphasis in spatial-econometric *deductive* approaches to theoretical models of interdependence processes, wherein space may often have broad meaning, well beyond physical distance to encompass all manner of social, economic, or political connection that induces effects from outcomes in some units on outcomes in others (see, e.g., recently, from economics and political science: Brueckner 2003; Beck et al. 2006). Spatial-lag models play starring roles in that tradition (Hordijk 1974; Paelinck & Klaassen 1979; Anselin 1980, 1988, 1992; LeSage 1999). According to Anselin (2002), such theory-driven models deal with substantive spatial correlation, and this approach lends itself to methods of model specification, estimation, and evaluation that begin with the unrestricted spatial lag model and use Wald-style testing to gauge the importance of spatial interdependence. On the other hand, spatial-error models, analysis of spatial-correlation patterns, spatial kriging, and spatial filtering, for examples, characterize the more-exclusively data-driven, i.e., *inductive*, approaches and the more-typically narrower conception of space in solely geographic/geometric terms in the longer spatial-statistics tradition (initially inspired by Sir Galton's famous comments at the 1888 meetings of the Royal Anthropological Society, and reaching methodological milestones in Whittle 1954; Cliff & Ord 1973, 1981; Besag 1974; Ord 1975; Ripley 1981; Cressie 1993). Again following Anselin (2002), this modeling approach stresses spatial patterns and clustering, seen more often as driven by data problems such as measurement error, and so tends to treat spatial correlation more as nuisance than substance. Such emphases lend themselves more naturally to the opposite direction in model specification, estimation, and evaluation, beginning with the restricted non-spatial model and adopting Lagrange-multiplier-style testing.[1] We would mention additionally only how the core questions asked and sorts of answers sought tend to differ across approaches. The core substantive distinction drawn in our proposal between spatial association arising from common exposure, contagion, or selection, and the challenges of separately identifying and estimating them are typically more centrally stressed from spatial-econometric perspectives (model specified deductively for purposes of inference about processes) than from spatial-statistical ones. Indeed, the fact of association will often suffice from a spatial-statistical vantage (inductive process of gaining information from the data), so the modeling approach often makes no attempt to distinguish them. Likewise, the kinds of counterfactuals of interest to us arise more naturally in a spatial-econometric than a spatial-statistical framework.

Network analysis, finally, considers a related (but not identical) set of substantive questions regarding the structure of *ties* (*edges*, *arcs*, *connections*) between *units* (*nodes*, *actors*, *vertices*). Central questions concern characterizing (measuring) the structure of networks, explaining their genesis, and, less centrally, at least until very recently, considering the effects of network structure and of units' location within it on units' actions (*behavior*, *attributes*). Again until perhaps recently, questions of how other units' (*alters*') actions affect each unit (*ego*) via the connections given by the network seem to have been less central still. Methods for network analysis seem to have originated primarily in sciences (physics, biology, computer-science) and mathematics, rather than in statistics or econometrics, and methodological development, including the eventual importation of statistical concepts, theories, and methods, has been largely separate from either spatial statistics or spatial econometrics (again, until recently perhaps), notwithstanding the similarity of their substantive interests.[2] The typical core questions of network analysis, thus, are subtly distinct from those of spatial econometrics and spatial statistics. Our own emphasis on *Galton's Problem*, the distinguishing of common exposure from interdependence (a.k.a., *contagion*) sources of spatial association, takes an important additional concern from a core network-analysis question of explaining network genesis, i.e., selection (a.k.a., *homophily*).

[1] A debate chronicled in *Regional Science and Urban Economics* (Florax et al. 2003, 2006 and Hendry 2006) continues as to whether one can demonstrate the inferential dominance of the bottom-up or top-down strategy.

[2] Consider, e.g., that the canonical reference in social-network analysis, Wasserman & Faust (1994) does not cite Cliff & Ord, Cressie, or Anselin, and that Carrington et al. (2005), intended as an update and companion to Wasserman & Faust cites only Cliff & Ord (1981) on just two pages of just one section and only with regard to Moran's I. Getis et al.'s (2004) *Spatial Econometrics and Spatial Statistics*, symmetrically, cites neither Wasserman & Faust nor Carrington et al.